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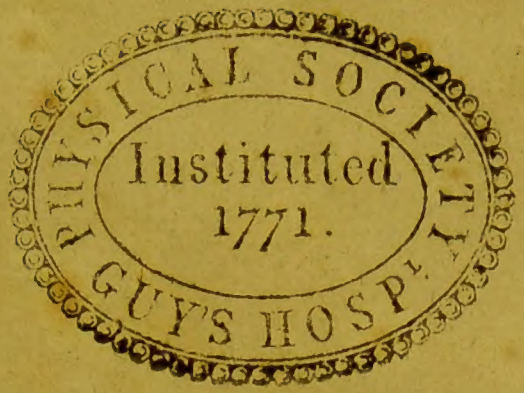
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LECTURES

ON

COMPARATIVE ANATOMY.

LECTURES
ON
COMPARATIVE ANATOMY.

TRANSLATED FROM THE FRENCH OF

G. CUVIER,

Member of the National Institute, Professor in the College of France, and in the
Central School of the Pantheon, &c.

By WILLIAM ROSS;

UNDER THE INSPECTION OF

JAMES MACARTNEY,

Lecturer on Comparative Anatomy and Physiology in St. Bartholomew's Hospital, &c.

VOL. II.

ON THE ORGANS OF SENSATION.

LONDON,

PRINTED, AT THE ORIENTAL PRESS, BY WILSON AND CO.
FOR T. N. LONGMAN AND O. REES, PATERNOSTER-ROW.

1802.

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LECTURES

ON

COMPARATIVE ANATOMY.

LECTURE EIGHTH.

*Of the Head, considered as the principal Receptacle
of the Organs of Sense.*

IN treating of the organs of motion, we considered the Head, as far as its figure, its motions, and the muscles which act upon it, were concerned. Were we to stop there, our knowledge of this portion of the body would be very imperfect. The history of its bones forms the principal part of Comparative Osteology, because they are the most variable and complicated of all the skeleton; and a knowledge of them is besides of great importance, on account of the number of essential parts which they either sustain or envelope. The brain—the principal nerves—the organs of seeing, hearing, smelling, and tasting—those of mastication and deglutition—and a part of those of respiration, and

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voice, are either enclosed within the Head, attached to some one of its bones, or pass through its holes and canals. Having concluded our treatise on the Organs of Motion, it is proper that we should now describe the Head, which will complete our System of Osteology, and commence an account of the Organs of Sense. We shall thus fix with precision the limits of each branch of our subject.

ARTICLE I.

Of the Cranium—of its Form, and its Proportions with respect to the Face.

THE Head allows of two principal divisions, 1st. the cranium, which forms an osseous case to enclose the brain; 2d. the face, which is made up of a collection of different bones, containing very complicated cavities, in which are lodged the organs of sight, smell and taste. The organs of hearing are situated in the lateral parietes of the cranium.

The two organs which occupy the greatest portion of the face are those of smell and taste. In proportion as the organs of these two senses are developed, the magnitude of the face, and its proportion, with respect to the cranium, is increased. On the contrary, as the brain is enlarged,

ged, the cranium which contains it augments in capacity, and becomes more considerable when compared with the face.

An extensive cranium and a small face, therefore, indicate a large brain, with little development of the organs of taste and smell; while a small cranium, and a large face, point out the opposite proportions—a brain of a small volume, with very perfect organs of taste and smelling.

The nature of each animal depends in a great measure on the relative energy of each of its functions, and it may be said to be influenced and governed by those sensations which are the most powerful. We observe daily illustrations of this truth among ourselves, though the differences which exist in that respect, between one man and another, are much less than those which may be remarked between other animals. We shall see hereafter that the brain, the common centre of all the nerves, is also the point in which all perceptions terminate, and the instrument by which the mind combines those perceptions, compares them, and makes deductions; in a word, reflects and thinks.

We shall also find that animals participate more in this last faculty, or at least appear to enjoy it more perfectly, in proportion as the mass of the medullary substance, which forms their brain, surpasses that which constitutes the remainder of their nervous system; that is to

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say, in proportion as the central organ of the senses exceeds their external organs.

The relative proportion of the cranium and the face, which indicates immediately that of the brain, with respect to two of the principal external senses, is likewise a mark of more or less perfection in the internal faculties. But another consideration adds to its importance as an index of this kind, which is, that the two senses we have mentioned are those which act with the greatest force on animals; those which govern them most powerfully in consequence of the energy which two of the strongest desires, hunger and love, communicate by the means of their perceptions. The actions to which these desires determine animals, are those into which they enter with the most blind fury, and the greatest bestiality, if we may be allowed to express ourselves thus, when man is not the subject of consideration.

It is not astonishing, therefore, that the form of the Head, and the proportions of the two parts which compose it, are indications of the faculties of animals, of their instinct, of their docility, and, in a word, of all their sensitive being. This circumstance renders the study of these proportions highly important to the Naturalist.

We shall soon find that man is the animal which has the largest cranium, and the smallest face; and that, according as this proportion is departed from in other animals, they become more stupid or more ferocious.

Among

Among the different means that have been employed to express conveniently the proportions of these parts, one of the most simple, but which is not always sufficient, is the *facial line* of Camper, and the angle which it forms with the base of the cranium. The facial line is supposed to pass along the edge of the superior dentes incisores, and the most prominent point of the forehead. The *basilar line* of the cranium is that which bisects longitudinally a plane passing through the external meatus auditorii, and the inferior edge of the anterior aperture of the nostrils. It is evident, that in proportion as the cranium is enlarged, the forehead must project more forward, and the facial line form a larger angle with the basilar. On the contrary, in proportion as the cranium diminishes in size, that line will incline farther back. We shall shew by a table, of the different sizes of the facial angle, that it is wider in man than in any other animal, and that it becomes always more acute in the mammalia, as they are removed from man, and in birds, reptiles and fishes. The vulgar are even accustomed to attribute stupidity to animals which have very long snouts, as cranes and woodcocks; but when some circumstances tend to elevate the facial line, without augmenting the capacity of the cranium, as we find takes place in the elephant and the owl, in consequence of the extraordinary thickness of the diploë of the os frontis, we fancy we see in

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animals of that description a peculiar air of intelligence, and are induced to ascribe to them qualities which they do not really possess. We know that the owl has been considered as the emblem of wisdom, and that the elephant has in India a name which indicates that he possesses reason.

The ancients appear to have been very sensible of these relations. They not only perceived that an elevated facial line was the indication of a noble nature, and one of the characteristics of beauty; but they even stepped beyond nature, and made this line incline somewhat more forward than it does in man, in figures to which they were desirous of giving a more than human air, as the statues of their gods, and those of their heroes, or men whom they wished should appear to partake of divinity. It seems they were desirous of placing man between beings of this sort, or a more perfect order, and brutes; and that they wished to indicate, by the opposite inclination of the forehead, that their heroes were still more removed than common men from the forms or the nature of the inferior animals.

A. *In Man and other Mammiferous Animals.*

The facial angle being determined in the manner I have pointed out, which is that of Camper, we find that in European heads this angle is usually

usually 80° , in Mongols 75° , and in Negroes 70° , with the variations of some degrees in respect to age and individuals. For example, the face in children is short, because their posterior teeth are wanting. This makes their facial line more perpendicular, and is one of the causes which renders their countenance always agreeable, and in consequence of which they become almost always less beautiful as they increase in age. The ancients, when they wished to impress an august character on their figures of men; have increased the facial angle to 90° , and they have even extended it to 100° in their figures of gods. This sinks the eyes more, and renders the branches of the lower jaw shorter than in nature.

In the *ourang outang*, the facial angle is 65° . In the *sapajous*, and the *guenons*, it is about 60° . In the *magots*, and the *macaques*, about 45° . Lastly, in the *mandrills*, which are the most mischievous and ferocious of all the apes, it is only 30° . In the species which have the ear much elevated, and the guttural cavity very deep, as the *Batavian pongo*, and the *alouatte*, the smallness of this angle does not indicate a proportional elongation of the snout. To demonstrate this accurately, the basilar line of the cranium should be drawn parallel to the base of the nostrils.

Even with this regulation, however, the facial angle is not important, with respect to the brain; except in the human species, and among the *Quadrumana*, because they have only very small

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frontal sinuses, which do not elevate the facial line in a sensible degree, and because the nose falls under that line.

But there are some quadrupeds, as the *Sarcophaga*, the *hogs*, some *Ruminantia*, and particularly the *elephant*, in which the frontal sinuses swell the cranium to such a degree, that they elevate the facial line much beyond what the proportion of the brain would require. In others, as the *morfe*, and the greater part of the *Rodentia*, the nose occupies so large a space that the cranium is inclined backward, and none of its parietes are entirely free anteriorly. In this conformation it is impossible to tell what ought to be the direction of the facial line. Lastly, the *Cetacea* have the cranium elevated in the form of a pyramid, and situated above a face which is very much prolonged, but flattened horizontally. The inclination of the facial line would be greater than it ought to be with respect to the real capacity of their face.

The following, however, is a table of the extent of the facial angle, in a certain number of animals, formed by drawing a line parallel to the base of the nostrils, and another passing along the anterior edge of the alveoli, and touching the convexity of the cranium, whether the point of contact be concealed by the face, or rise above it.

European Infant	-	-	-	-	90°.
European Adult	-	-	-	-	85°.
					Aged

Aged European	-	-	-	-	75°.
Adult Negro	-	-	-	-	70°.
Young Ourang-outang	-	-	-	-	67°.
Sapajou	-	-	-	-	65°.
Talapoin Monkey	-	-	-	-	57°.
Young Mandrill	-	-	-	-	42°.
Coati	-	-	-	-	28°.
Pole-cat	-	-	-	-	31°.
Pug-dog	-	-	-	-	35°.
Mastiff-dog, the tangent taken at the external surface of the cranium					41°.
———— at the internal surface	-				30°.
Hyæna, at the external surface	-				40°.
———— at the internal	-	-	-	-	25°.
Leopard, at the internal surface	-				28°.
(A tangent cannot be drawn to the external surface, on account of the convexity of the nose.)					
Hare	-	-	-	-	30°.
Marmotte	-	-	-	-	25°.
Porcupine	-	-	-	-	23°.
The three last are measured by the internal sur- face of the cranium, because a tangent cannot be brought to the external.					
Pangolin	-	-	-	-	39°.
Babirouffa	-	-	-	-	29°.
Ram	-	-	-	-	30°.
Horse	-	-	-	-	23°.
Dolphin	-	-	-	-	25°.

We may, however, discover more important relations, in considering the cranium and the face,

face, under the vertical and longitudinal section of the Head. With respect to their relative proportions, the cranium, in this section, occupies an area sometimes greater, sometimes less, and sometimes nearly equal to that of the face.

In the *European*, the area of the section of the cranium is almost four times greater than that of the face, the lower jaw not included.

In the *Negro*, the cranium remaining the same, the area of the section of the face is increased about one-fifth. In the *Calmuc*, it increases only one-tenth.

The proportion is less in the *ourang outang*. In the *sapajous*, the area of the face is almost one-half of the cranium. It is nearly equal in the *mandrills*, and in most of the Carnivora, except in the varieties of short-nosed dogs, as the *pug*, which have the face somewhat smaller in proportion to the cranium. The Rodentia, the Pachydermata, the Ruminantia, and the Solipeda, have all the area of the section of the face larger than that of the cranium. In the Rodentia, the *hare*, and the *marmotte*, have it one-third larger. It is more than double in the *porcupine*. It is nearly double in the Ruminantia; a little more than double in *hogs*, nearly triple in the *bippopotamus*, and almost quadruple in the *horse*.

The *morfe* and the *elephant* have a large face, in consequence of the height of the alveoli; but it cannot, in them, be considered as augmenting the extent of the organs of sense.

The

The Cetacea have the cranium very globular, and the face very flat, in consequence of which the area of the latter is proportionally diminished; besides, the face is not occupied by the nose throughout its whole extent, and ought not to be considered here under this relation. The area of the face in the *dolphin* is perhaps about one-third larger than that of the cranium.

With respect to figure; were the curve of the human cranium continued inferiorly from the foramen magnum to the root of the nose, the section would form an oval which would be a little narrowed anteriorly, and of which the greatest axis would be nearly parallel to the floor of the nostrils, or at least inclined very little backward, and its proportion to the small axis would be as 5 : 4. But in the space I have pointed out, and which forms the limits of the cranium and the face, there is, instead of this curve, an irregular line forming a salient angle within the oval. The section of the face is a triangle, with its greatest side towards the cranium, and the smallest directed outward. The angle, which the latter forms with the third side, or the palate, is precisely the facial angle.

In *monkies*, the great axis is somewhat elongated with respect to the lesser; the line which separates the cranium and the face becomes more straight, and the anterior and inferior side of the triangle of the face is so much elongated, that
the

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the side which touches the cranium is the smallest of the three in the *macaques* and the *mandrills*. It is found the least also in other quadrupeds. In the *Sarcophaga* and the *Rodentia*, the anterior part of the oval of the cranium is the narrowest. In the *Ruminantia*, and the *borse*, the posterior is the most narrow. We perceive a strong angle within the cavity of the cranium of those that have an osseous separation between the cerebrum and the cerebellum.

The great axis of the oval inclines forward in the *Sarcophaga*, with respect to the base of the nostrils, but backward in all the herbivorous species. Its form and direction in the *morse* are the same in the *Sarcophaga*.

The section of the cranium of the *dolphin* is almost triangular, the sides are convex, and the angles rounded. One side is anterior; another, which is posterior, is perforated by the foramen magnum. The third, which forms the base of the cranium, and which corresponds with the line that unites the cranium to the face, in other animals, is, however, situated completely behind the face, and is even parallel to the arch of the palate.

We may also examine the transverse vertical section of the cranium, that is to say, a section made by a plane perpendicular to its great axis.

This forms in man a very considerable portion of a circle, wanting only a segment somewhat less than a third of the circumference towards the inferior

inferior part. The cranium of the *Negro* is flatter on the sides than that of the *European*, because his temporal fossæ are greater and deeper. This diminishes his face upwards, but enlarges it inferiorly on account of the prominence of the cheeks.

In the *Sarcophaga* this section produces a semi-ellipsis rounded towards the upper part, and having the base nearly equal to its height.

In the *hog*, it is an oval which is longest vertically, and the sides of which are made irregular by large angles towards the pars petrosa directed interiorly.

In the *horse*, the oval is more broad than high, and the inferior half has nearly the same curvature as the superior.

These remarks are the more interesting, as in all mammalia the brain is molded in the cavity of the cranium, which it fills exactly; so that the description of the osseous part affords us a knowledge of at least the external form of that medullary mass.

B. *In Birds.*

The longitudinal and vertical section of the cranium in birds generally represents an oval, with its narrowest part anteriorly, the side corresponding to the face less convex than that which is superior and posterior, and the great axis directed upward and forward. The *owls*
are

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are the only birds in which this section is oval, and contracted nearly equally above and below, with the great axis almost vertical.

The face of birds being chiefly formed by their bill, their physiognomy depends upon the thickness and length of that part; but as the nose occupies a very small portion of it, and as the tongue is frequently so small as to take up very little room in the mouth, the proportion which the cranium bears to the face does not afford the same inductions in birds as in quadrupeds.

C. *In Reptiles and Fishes.*

As the brain of reptiles and fishes occupies only a small part of the cavity of their cranium, no important consequences can be deduced from its shape and size. In the *tortoise* this cavity is large, narrow from right to left, elevated anteriorly, and depressed posteriorly. Its lateral parietes are almost vertical, and its base is parallel to the palate. The external form of the head, and its apparent magnitude, are occasioned by the accessory bones, between which and the cranium there is a large space occupied by muscles and glands.

The small size of the cavity of the cranium, with respect to the external bulk of the head, is still more extraordinary in the *crocodile*. In an individual four metres long, that cavity will hardly

hardly admit the thumb, and the area of the section of the cranium is not one-twentieth part of that of the whole head. The figure of the section is oblong, rather larger anteriorly, and descending posteriorly. There is a considerable depression for the pituitary gland. Its breadth is equal to its height; and the lateral parts of the head, as in the tortoise, cover only the temporal fossæ.

The cranium of *frogs* and *salamanders* is almost prismatic.

That of *fishes* is generally very small in proportion to the rest of the head, but it varies greatly with respect to its form, and cannot be compared either with the brain or the surrounding parts. Its shape, however, approaches most frequently to an oval.

ARTICLE II.

Of the Bones which compose the Cranium.

A. *In Man.*

THE osseous case which forms the cranium, is divided into a certain number of bones, which are joined by immoveable articulations, called *sutures*. These disappear more or less with age, because the reciprocal indentations by which

the edges of the contiguous bones are united, are sooner or later ossified together. As there exists, however, always some traces of the separations of the bones, and as their situation or disposition is varied in different animals, a knowledge of them becomes highly useful to the Anatomist, who wishes to discover the part and the kind of cranium to which fragments of fossil heads should be referred. We shall examine these sutures, or lines of separation between each of the bones of the cranium, in the different kinds of animals, beginning with Man.

The human cranium is composed of eight bones; they are all supported on one of their number, which is situated at the base of the cranium, to the arch of which it may be said to serve as the key. It has been compared to the figure of a bat, and is called *os sphenoides*, or *os cuneiforme*, because it answers the purpose of a wedge, with respect to the bones between which it is enclosed.

We shall here consider its shape abstractedly from its eminences and holes. It is bounded before by a curved line, the concavity of which is anterior, and which is continued obliquely on the bottom of each orbit of the eye, the external side and bottom of which are occupied by the sphenoid bone. This line is called the *sphenoidal suture*. At the temporal angle of the orbit, it is directed backward in the temporal fossa, until it comes in contact with the *os temporum*. It
separates

separates the sphenoid from the frontal bone throughout almost its whole length; the two extremities of the os sphenoides only touch the parietal bones. It is bounded on each side by another curved line, which makes an acute angle with the first, and which separates the sphenoid from the temporal bone; this is called the *sphenotemporal*, or *temporal suture*. The concavity of the bone is external; as it approaches the middle it descends and is carried backwards, so that the posterior border of the bone is much less extensive than the anterior; the posterior border is divided into three lines, which are nearly straight; a middle one, which is parallel to the middle of its anterior margin; and two lateral lines, directed obliquely backward, each uniting with the external margin of the same side by an acute angle. The middle part of the posterior margin separates the os sphenoides from the os occipitis. This, which is called the *basilar suture*, exists only in youth. The two bones are afterwards united, and form only one; its lateral parts separate it from the pars petrosa of the os temporum. The longitudinal axis of the os sphenoides is nearly one half the length of its posterior margin, and somewhat more than a fourth of the anterior.

All the bones of the cranium are separated by lines which proceed from different points of the os sphenoides. The *frontal* or *coronal suture* extends from a point very near the lateral superior

angle of this bone, to the corresponding point on the other side, crossing the arch of the cranium almost at the top. This suture is the posterior boundary of the bone which forms the forehead, and the superior arch of the orbits. The name given to this bone is the *os frontis*. In children it is divided by a longitudinal suture, which sometimes remains even at a very advanced age. This separation is marked in some skulls by a pretty conspicuous depression, and in others by a ridge more or less elevated. It is called the *medial* or *proper frontal* suture. The *os frontis* is nearly of a semi-circular form. It is truncated inferiorly, and bends backward to form the arch of the orbits. Its vertical height is nearly two-thirds of its breadth.

At the external and superior angle of the sphenoid bone, another suture commences, which is continued along the edge of the *os temporum*; the curve it forms is nearly circular. It is called the *squamous suture*, because the edges of the bones which form it have the appearance of scales; the superior and internal edge of the *os temporum*, covering the external and inferior edge of the *os parietale*. After describing about one-third of a circle, the edge of the temporal bone turns up, forms with the suture an obtuse and inward angle and is directed posteriorly until it reaches the *os occipitis*.

A line proceeds from each side of the point where the basilar joins the petro-sphenoidal suture,

ture, and separates the pars petrosa from the os occipitis; these two lines bend outward until they arrive opposite the middle of each occipital condyle, where they are suddenly carried backward, and re-ascend a little to finish the outline of the temporal bone. All this posterior part of the edge of the bone is called the *mastoid suture*.

The thin, and almost circular portions of the ossa temporum, form a part of the lateral parietes of the cranium. The posterior edge of the temporal bone is rounded as it advances to join the occipital. Its inferior edge produces that thick and hard prominence, called os petrosum, situated between the basilar process and the posterior lateral edge of the os sphenoides, and thus forming a part of the base of the cranium. This pars petrosa is separated from the rest of the bone in the human foetus: it extends from the back part obliquely inward and forward.

The *lambdoidal* or *occipito-parietal* suture, which concludes the figure of the os occipitis, begins at the middle of the mastoid suture, and ascends somewhat posteriorly, so as to form an angle with the corresponding suture. It unites the occipital with the parietal bones, which complete the superior arch of the cranium. The portion of the occipital bone included between the foramen magnum and the os sphenoides, is called the *basilar* or *cuneiform* process. It is almost square in man, narrowed a little anteriorly, and very short.

short. In youth it is separated from the rest of the bone by two futures which intersect the anterior portion of the condyles. The remainder of the bone, which forms what is properly called the occiput, is of an oval form, very concave internally, and pointed superiorly. Its position is such, that when the human body is erect, the cuneiform process ascends somewhat forward, and its other part is directed backward.

The ossa parietalia are separated from each other by a longitudinal line, called the *parietal* or *sagittal* future. The shape of these bones is quadrangular, the edge by which they touch each other is the longest. Their temporal margin is the shortest and the most concave. Their convexity is nearly uniform.

The os frontis has a vacant space between the two orbits, which is occupied by the cribriform lamella of the os ethmoides. The form of this space is that of a long square. It is bounded posteriorly by the os sphenoides. The line of separation is called the *ethmoidal* future.

B. *In other Mammiferous Animals.*

The principal differences observable in the cranium of mammiferous animals, consist in the number of the bones which constitute it ; in the connections of these bones ; and, lastly, in the particular form which each of them assumes. We shall proceed to consider the craniums of
the

the different families of mammalia under these three general points of view.

1. *Number of the Bones of the Cranium in Mammalia.*

All the Quadrumana have eight bones in the cranium, but the os sphencoides is frequently divided into two parts; one of which forms the orbitar wings, and the anterior clinoid processes; and the other the temporal wings, the posterior clinoid processes, and the basilar fossa. The two ossa parietalia unite together at a very early period in the Chiroptera, so as to form only one bone; the same thing takes place in almost all the other Sarcophaga, which also generally have the os frontis divided into two parts by a medial future. The cavity of the tympanum is separated from the rest of the temporal bone, by a future, which seldom ossifies in the *cat*, *dog*, and *civet* genera.

This cavity is also separated in the Rodentia, and the os frontis remains divided into two parts. Their parietal bone is sometimes single, as in the *bears*, the *cavys*, the *porcupine*, the *marmotte*, the *rats*, and *squirrels*; and sometimes double, as in the *mice*, the *dormice*, and the *rabbit*.

The os frontis and the ossa parietalia of the *elephant* are, at a very early period, united by ossi-

fication with all the other bones of the cranium; so that the whole forms a brain-case, in which no traces of the futures appear.

In the *bog*, the *tapir*, and the *hippopotamus*, the two parietalia form only one piece. Their os frontis is double: the *rhinoceros* has the frontal and parietal bones double, but the separation of the last soon ossifies. The os sphenoides of the animals of this and the two succeeding families, remains for a long time divided into two parts. The one forms the orbitar wing, or the little wings of Ingrassias; the other produces the large wings, or temporal processes, which are here much the smallest. This disposition is exactly the opposite of that observed in man.

In the Ruminantia and Solipeda the os frontis remains for a considerable time divided by a medial future. In these animals the place of the two parietalia is supplied by a single piece which forms the top of the cranium. The cavity of the tympanum is always distinct.

The *seals* have two parietalia, and the os frontis divided into two parts; this also takes place in the *morfe*. The *lamantin* has only one parietal bone, and the cavity of the tympanum is separated from the body of the temporal bone.

In the Cetacea the parietalia are very soon united with the occipital and temporal bones, in such a manner that these five bones form only one. The bone of the ear is always separate, and is connected with the cranium only by soft parts.

parts. The sphenoides remains long distinct, and is even divided into several pieces.

2. *Connections of the Bones of the Cranium in Mammalia.*

Of all the Quadrumana, the *orang-outang* has the cranium most similar to that of man in its form. It differs however in the connection of the bones. The temporal wing of the os sphenoides is extremely narrow, and does not extend to the parietal bone. It touches the os frontis with its superior extremity only, so that the temporal partly articulates with the frontal bone. The temporal suture is indented, and the edges of the bone are not squamous. In the *jocko*, this portion of the temporal wing neither touches the os frontis nor the ossa parietalia; but the os temporum articulates immediately with the os malæ, by its squamous part.

In the *mandrils*, the *macaques*, the *magots*, and the *guenons*, the connection is the same as in the *orang-outang*.

In the *sapajous*, the os frontis does not come in contact with the temporal wing of the sphenoid bone, and the parietal articulates with the cheek-bone. In the *alouates* the connection is the same as in man.

The connections of the bones of the cranium with each other are the same in all the *Sarcophaga* as in man.

In all the Rodentia, the os sphenoides only articulates with the os frontis, and ossa temporum, without touching the ossa parietalia. Its extent in the orbital and temporal fossa is very limited.

In the *armadillos*, the *pangolins*, and the *shoats*, we discover the same connections as in the Rodentia; but in the *ant-eaters*, the ossa parietalia are carried under the cranium, and unite in a very extensive manner with the os sphenoides, at the posterior part of the temporal and orbital fossa.

In the *elephant*, the bones of the cranium are, at a very early period, united by ossification, and form only one piece. The bone of the ear is always distinct and separate from the os temporum.

In the *hog*, the *tapir*, the *rhinoceros*, and the *hippopotamus*, the os sphenoides does not unite with the parietal bones, and its large wings occupy only a very small space in the orbital and temporal fossa. Only a small part of the orbital processes appear externally, though they are extended much farther than the large wings. The bone of the ear, which is very distinct, is, however, ossified at its base to the circumference of the meatus auditorius.

The os sphenoides of the Ruminantia articulates, as in man, with all the other bones of the cranium, but its orbital wing, which is very extensive, is concealed in a great measure within
the

the cerebral cavity, and covered by the orbitar lamella of the os frontis.

In the Cetacea in general, the futures which exist after an early age are all of the squamous kind.

3. *Forms of the Bones of the Cranium in the Mammalia.*

The shape of the os frontis is more irregular in the orang-outang than in man. The arch of the orbits is less depressed. In the *sapajous*, the frontal bone has the form of a triangle, and terminates in a point towards the crown of the head. In the other *monkies*, this bone is nearly oval, and the orbitar arches almost straight. These arches form, in all monkies, as well as in man, the anterior margin of the os frontis, because the root of the nose is very narrow. In the *makis* it begins to assume a broad shape, and the eyes become oblique. This gives a rhomboidal form to their os frontis.

The os frontis of the Sarcophaga, and in general of all the succeeding mammalia down to the Cetacea, exhibits the irregular surface of a prism or cylinder, in which three principal surfaces should be considered; one superior, which is connected with the nose anteriorly, and with the rest of the cranium posteriorly; and two lateral, which descend each into the orbitar and temporal fossa of the same side.

The

The form of the superior surface is principally determined by the position of the orbits. In *dogs, cats, bears, ternate-bats, weasels, oppossums, &c.* these orbits correspond with the anterior part of its lateral margins, and give to the whole bone a rhomboidal figure. In the Rodentia, the orbits form notches in the middle part of the lateral edges of the os frontis, and give to it a form more or less rectangular.

It is the same in the *flying-lemur*.

The *hedge-hogs, the moles, the shrews, the anteaters, the seals, the morfes, and the rhinoceroses* have no orbital arches properly so called. The frontal bone is simply contracted, and becomes almost cylindrical between the orbits. It is enlarged posteriorly.

In the *hippopotamus*, the Ruminantia, and the Solipeda, the frontal bone is enlarged, and forms a vault over each orbit.

Lastly, in the Cetacea, the os frontis is narrow from the front backward. It resembles a fillet extended across the cranium; but as, according to the laws which govern the structure of the head in mammiferous animals, this bone should form the upper part of the orbits; it descends for that purpose below the maxillary bones, so that the order of the position of the bones in these animals is entirely reversed to preserve that of their connections.

The ossa parietalia of the *orang-outang*, differ only from those of man in having their
temporal

temporal edges almost straight; those of the *monkeys* are narrower, and their angles become more oblique in proportion as the cranium is flat. They return almost to a rectangular form in the *Sarcophaga* and the *Edentata*. We have already shown that they are united into a single piece in a considerable number of the *Rodentia*. That piece is almost nearly square; but it is sometimes flat, sometimes rounded, and sometimes surmounted with a crest.

The *Ruminantia* have also a parietal bone in a single piece. In the *stags*, the greater part of the *antelopes*, the *sheep*, and the *goats*, it is broad, and a narrow slip extends on each side of the temporal fossa. It is situated before the occipital arch. In the *camel* it is narrow, and has a longitudinal crest. In the *ox*, and in the *antelope-bubalis*, it is situated behind the occipital crest, and resembles a ribbon surrounding the posterior part of the head transversely.

In the *Solipeda*, the parietal bone, which is single, is almost square, and situated before the occipital crest.

We have already explained the forms of the os occipitis in the first volume, when describing the motions of the head on the spine.

We shall at present only notice the squamous part of the os temporum, reserving our account of the pars petrosa until we treat of the ear. In the *orang-outang* and most *apes*, the squamous portion of the os temporum is of a trapezoid figure,

figure; the superior side is the longest, and its height varies according as the cranium is more or less elevated. It is shortest in the *sapajous*.

The squamous portion in the *Sarcophaga* is similar to that of the apes.

In the *Rodentia* it is very narrow posteriorly.

In the short-nosed *Edentata*, in the *Ruminantia*, and the *Pachydermata*, it is rounded a little.

It is necessary to remark, that the mastoid process forms a part of this bone only in *man* and *monkeys*, and that in all the other *mammalia* it belongs to the *os occipitis*.

We shall describe the zygomatic process of the *os temporum* when we treat of the face, and particularly of mastication.

The *os ethmoides* shall be described when we treat of the sense of smelling.

The *os sphenoides* has been sufficiently explained, and we shall have no occasion to return to it. Its processes will be described in our account of the bones of the face.

C. In Birds.

The bones which compose the cranium of birds, are united at an early period, and the sutures cannot be perceived except in very young subjects.

These bones correspond in their number and position to those of the *mammalia*. There are
two

two frontal bones which are prolonged anteriorly to form the roof of the orbits. When birds have a horn, or a crest, it is also attached to the os frontis.

There are two small ossa parietalia behind the frontal bones.

The ossa temporum occupy the sides of the cranium and the auricular region.

The os sphenoides cannot be distinguished from the occipital bone, even in subjects that have the futures very conspicuous.

It should be further remarked, that this sphenoccipital bone unites with the ossa temporum sooner than the other bones unite with each other.

In new-hatched birds, however, we observe a future which extends transversely in a straight line from the one ear to the other, and which separates the sphenoid from the occipital bone; the latter is then nearly of an annular form, and is subdivided into four portions; one superior, two lateral, and one inferior, which is very small.

The os sphenoides forms the greater part of the base of the cranium. It is almost triangular, and has anteriorly a small eminence, which articulates with the palatine arches, which we shall describe when we treat of the face. It wants the pterygoid processes, and does not come in contact with the posterior aperture of the nostrils.

The

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The temporal bone has no zygomatic process, but there is a small apophysis which contributes to the formation of the posterior margin of the orbit.

The os frontis having covered a part of the cranium, is prolonged forward into a lamina more or less broad, which forms the superior part of the orbits, and the lateral edges of which are usually notched by these fossæ. The two orbits are separated from each other by only a vertical lamina, which also belongs to the os frontis, and which is attached to the plate that forms their roof.

The osseous eminences which we observe on the heads of the *cassowary*, the *horn-bill*, the *pintado*, and some *curasows*, &c. are enlargements of this supra-orbital portion. Their interior is filled with diploë of a very loose texture.

D. *In reptiles.*

The bone of the base of the skull in the *crocodile* has the form of a very irregular truncated pyramid. The point of this pyramid is downward, and its base contains the cavity of the cranium. This pyramid has three surfaces, one posterior, which forms the occiput, and two lateral. The occipital surface is almost triangular; one of its angles is inferior, the other two are superior, and greatly prolonged backwards and to the side, in order to form the

enormous articular processes, which receive the lower jaw. Their position is almost horizontal. The foramen magnum is situated in the middle of this surface, and under it the single condyle for articulating the head with the vertebral column.

Three futures depart from the foramen magnum, which divide the occiput into particular bones. The superior part of the cranium is formed by a single parietal bone. Anterior to it, there is an os frontis, also single, which forms the roof of the orbits.

The ossa temporum are situated on each side of the parietal bone, and are partly supported by that articular process for the lower jaw already mentioned.

A small arch on each side, different from the zygoma, leaves between it and the parietal bone a large round hole, which perforates the temporal fossa. The arch is partly formed by a process of the os temporum, and partly by a particular bone articulated to the junction of the parietal and frontal. This particular bone occupies the place of the post-orbital process of the os frontis in the mammalia; for it descends behind the orbit to join the cheek-bone, and with it finishes the frame of the orbit.

A cranium similar to this of the *crocodile*, is found in the other *lizards*, notwithstanding the great differences in the form, proportion, and the direction of the parts. In the *camelion*, therefore, the foramina by which the temporal
fossæ

fossæ communicate with the cranium, are so large, and the bony edges which form them so thin, that the latter represent three slender branches rising to support the kind of helmet which distinguishes this animal. The articular processes are not directed backward, but downward.

The last peculiarity is also observed in the other *lizards*, but they have not the crests of the *camelion*, and the upper part of their cranium is broad like the *crocodiles*.

In *frogs* and *salamanders* the cranium is nearly of a cylindrical form, flat superiorly, and enlarged posteriorly; the frontal bones have the shape of an elongated rectangle, and occupy the interval of the orbits. The *Surinam toad* has the cranium much flatter than the other genera.

The eminences intended to assist in the articulation of the jaw are turned directly towards the sides.

The structure of the cranium of *tortoises* bears more resemblance to that of crocodiles than of frogs. The frontal bones form only the roof of the orbits, and the cranium does not pass between these cavities. They are very short, and the parietalia are three times longer. The latter are not confined to covering the cranium. They extend on each side, and form an arch over the temporal fossa. In the *sea tortoises* this arch is completed by two peculiar bones which extend from the os parietale to the zygoma, and the anterior of which bounds the orbit behind.

The

The articular processes are directed downward, as in the camelion. Above these and the meatus auditorius, we find considerable mastoid processes which are pointed superiorly in *land tortoises*, but are rounded and marked by a longitudinal furrow in the *sea tortoises*.

Serpents have two frontal bones almost square, and a single parietal bone. Their cranium advances forward between the orbits, as in frogs. The occipital bone has a process directed backward, and connected with a particular moveable bone, analogous to the square bones of birds, to which the lower jaw, and the arches which form the upper, are articulated.

E. *In Fishes.*

The bones of the cranium of fishes are soon ossified together, and as the sutures which unite them are squamous, it is not easy to discover any traces of their separation. The cranium of fishes forms in general a very small portion of the head. Its figure varies considerably; but as it is covered with skin only, its forms appear externally; these have therefore been well described by Naturalists, and we have no occasion to give any account of them here.

ARTICLE III.

*Of the Eminences and Depressions of the Internal Surface of the Cranium.*A. *In Man.*

THE superior part of the cranium is almost quite smooth internally ; it is only slightly marked by the vessels of the dura mater, and the circumvolutions of the brain. The most remarkable of the impressions thus produced, is that which extends along the whole of the middle of this vault, and which corresponds to the longitudinal sinus. The base or floor of the cranium, however, is more unequal, and we observe in it some very conspicuous cavities and eminences. It may be divided into three regions or large fossæ.

The *posterior fossa* is named *cerebellous*, because it is chiefly occupied by the cerebellum. It is the deepest of the three, and has also been called the *inferior occipital fossa*. Its lowest part is perforated by the foramen magnum of the os occipitis. A slight excavation ascends obliquely forward from this foramen, and terminates anteriorly by an elevated ridge, having on each side a small hook, denominated *posterior clinoid process*. This ridge forms the anterior boundary of the fossa. It is an apophysis of the os sphenoides ;

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noides; but the broad canal situated behind it is chiefly formed by the cuneiform process of the occipital bone, and is called the *basilar fossa*.

Another projecting ridge extends from each side of the clinoid process, and is directed obliquely backward. This ridge belongs to the petrous portion of the temporal bone, and completes the anterior limits of the large cerebellous fossa. This fossa is inclosed posteriorly by an elevated line proceeding like the branches of a cross from the tuberosity in the middle of the os occipitis. Another elevated line, which proceeds likewise from this tuberosity, descends to the edge of the foramen magnum, and divides the cerebellous fossa into two parts, throughout the whole of its length. In this fossa there also appear some impressions of vessels, of which we shall speak hereafter.

The level of the *anterior fossa* is more elevated than that of the other two. It is situated above the orbits and the nose. It is united anteriorly, without any conspicuous separation, to the superior vault of the cranium. Posteriorly it is separated from the middle fossæ by a sharp ridge, which is concave on the back part, and formed by the orbital wing of the os sphenoides. These two ridges extend towards the middle line, and backward. They are terminated nearly opposite to the posterior clinoid processes, but somewhat more outward, each by a hook called *anterior clinoid process*; the interval between these two

hook consists of another ridge, but less sharp, which completes the boundary of this fossa posteriorly. The middle of the fossa is more depressed; it is formed by the cribriform lamella of the os ethmoides, which bears on its middle a sharp edged ridge in the form of a ploughshare, called the *crista galli*, or *ethmoidal crest*. Its lateral parts are convex and scabrous.

The *middle fossæ* of the cranium occupy the space between the anterior and posterior; their limits have therefore been already described. Their level is intermediate between that of the other two. As the anterior and posterior fossæ are more extensive towards the middle than at their sides, they approach each other at that part. The interval, which separates them, and which is situated between the four clinoid processes, is more elevated than the middle fossæ, and is denominated *sella turcica*, or *sella sphenoidalis*.

B. In other Mammiferous Animals.

The three large fossæ of the cranium exist in the inferior mammalia; but they are less deep, and the eminences which separate them are effaced in proportion as the animal is removed from man. Even in the *jocko*, we begin to observe, that the cerebellous fossa is nearly on a level with the middle fossa; that the sella turcica is less marked, and that the ridge of the small
wings

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wings is less eminent. The cribriform lamella of the os ethmoides is more depressed, and has no crest.

The *mandrils*, the *magots*, and different species of *guenons*, differ from the jocko, only in having their posterior fossa narrower, and not so deep; while their os petrosum extends directly backward, and the occipital surface of their cranium is more elevated. The frontal fossa has two lateral convexities, which are more globular, particularly in the *guenons*.

In the *sapajous*, the orbital wings of the os sphenoides have no ridge. Instead of the anterior fossa, there is only a convexity: the intermediate fossæ are as deep as the posterior. The fella turcica is nearly on a level with them, and the cribriform lamella is situated in a narrow depression.

In the *alouates*, the posterior and the intermediate fossæ, and the fella turcica, form only one plane, from which the two ossa petrosa, and the four clinoid processes, arise. Instead of the anterior fossa, there is an oblique surface, the middle of which is depressed, and leads to a very small cribriform lamella.

The same level exists in the different parts of the base of the cranium in all the *Sarcophaga*, in which the anterior fossa is seldom distinguished from the intermediate fossæ, but forms merely a short and broad canal, terminated anteriorly by a very large cribriform lamella. It must be observed,

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however, that, in the *bear*, the middle fossæ are separated from the anterior fossa by a ridge attached to the side of the cranium, and belonging partly to the os frontis, and partly to the os parietale. In the *seal*, on the contrary, there is no anterior fossa, properly so called, as the front of the cranium rises perpendicularly like a wall, and has the cribriform lamella in its superior part. The superior fossa is more conspicuous in the *moose*. With respect to all these animals, it will be easily conceived, that, in proportion as the cerebellous fossa is flattened, and the foramen magnum is directed backward and upward, the basilar fossa must be elongated. At the same time the posterior boundary of the cerebellous fossa will ascend, and terminate by forming a girdle, dividing the cranium vertically, and situated before the cerebellum. In the greater part of the *Sarcophaga*, the cerebellous fossa is formed by a broad and thin projecting lamina, which continues over the ossa petrosa, and seems to form a particular cavity for the cerebellum. The *Sarcophaga* have no sella turcica, properly so called, and their clinoid processes are very small.

The base of the cranium is very level in the *Rodentia*. There is no distinction between the anterior and the middle fossæ. The ridge of the pars petrosa is obtuse. Only a few species, as the *hares* and the *agoutis*, have the clinoid processes. The place which corresponds with the
situation.

situation of the sella turcica is even depressed in the *cavy*.

There is also very little difference as to level in the fossæ of the cranium of the *Edentata*. Their cribriform lamella is situated in a depression distinguished by a vertical ridge. The limit between the middle and posterior fossæ is not very apparent in the *flots*, the *armadillos*, and the *ant-eaters*; but in the *pangolin* it is a large vertical septum, perforated by an oval hole in the middle.

The three fossæ are very distinct in the *elephant*. The middle is the most depressed; they are separated by blunt elevations: the cribriform lamella occupies almost the whole of the bottom of the anterior fossa, because the nose of this animal is situated under the cranium, as in *Man*, and not before it, as in the *Sarcophaga*, the *Rodentia*, &c. The sella turcica is not very much elevated. The clinoid processes are short, particularly the posterior.

The anterior and the middle fossæ are not distinguished from each other in the *rhinoceros*. The posterior fossa is deeper than the others, and is separated from the middle fossæ by an acute elevated ridge, which is situated before them, but is not attached to the pars petrosa. The part which corresponds to the sella turcica is considerably more depressed than the middle fossa, instead of being elevated, as in *man*. The part answering to the posterior clinoid processes is not

attached, as in other animals, to the base of the cranium, but extends like a bridge from the one middle fossa to the other; while the fella turcica, which, as we have observed, is lower than these fossæ, communicates under this bridge with the cuneiform process of the os occipitis.

The three fossæ, and the fella turcica, are on the same level in the *hippopotamus*, and cannot be distinguished from each other, except by a projecting lamina, which corresponds to the posterior clinoid processes. The ossa petrosa, the figure of which is very irregular, project into the cranium, but they form no regular partitions. It is the same with respect to the *tapir*; but, in the *bog*, the posterior fossa is lower than the others, and is distinguished from them, as in the *rhinoceros*, by an elevation situated before the ossa petrosa. The posterior clinoid processes are attached to the bottom of the cranium; the anterior processes do not exist, and the part which corresponds to the fella turcica is depressed and very broad. The anterior fossa is distinguished from the middle, merely by a little more elevation, and a slight convexity. All these Pachydermata have the cribriform lamella of the os ethmoides very broad, much depressed, and divided into two parts by a very thick crest.

In the Ruminantia the middle fossæ are scarcely perceptible from the anterior. The fella tur-
cica

cica is very broad, and considerably lower than the middle fossæ, between which it is situated. It continues on the same level with the posterior fossæ, without any distinctive mark, except a small lamella, which corresponds to the posterior clinoid processes. The fella turcica of *stags* and *camels* is less depressed than that of the other genera. The cribriform lamellæ of the os ethmoides are broad, but they are more depressed, and separated by a broader crest in the *camel* than in the other genera. In the *chevrotins*, the anterior fossa is proportionally somewhat more elevated than the middle fossæ.

In the Solipeda the fella turcica is less depressed than in the greater part of the Ruminantia. On each os petrosus there is an elevated ridge, which extends to the superior vault of the cranium, as in the Sarcophaga.

In the Cetacea the cerebellous fossa is distinguished from the middle fossæ by a lateral partition, but the whole base of the cranium is nearly level, and there is neither ethmoidal fossa, nor cribriform lamella. The middle fossæ are much separated from each other, and a little more elevated than the cerebellous. There are no clinoid processes; the line of division between the middle and posterior fossæ is not formed by the os petrosus; that ridge is situated before it.

C. In Birds.

The cranium of birds is divided into two principal fossæ, one of which is situated above and somewhat before the other. The first contains the cerebrum, properly so called, and consequently corresponds to the anterior and part of the middle fossæ of the human skull. The second contains the thalami nervorum optico-rum, the cerebellum and the medulla oblongata, and corresponds to a part of the middle fossæ and the cerebellous fossa of man. The line which separates these two fossæ is sharp and horizontal on the sides, but, posteriorly, it ascends and forms an arch above the cerebellum. The superior fossa is separated into two parts, by a slight convex eminence, produced by the roof of the orbit; but the inferior fossa presents several remarkable cavities.

In the first place, there is, on each side, under the ridge which separates it from the first fossa, a round cavity which contains the corresponding thalamus. Between these two optic cavities there is another which corresponds to the sella turcica, and in which we observe a particular excavation for the pituitary gland. These three little fossæ form together a kind of arch, the convexity of which is directed forward. In the concavity of this arch, and before the foramen

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men magnum, there is a fourth fossa, which corresponds to the basilar fossa in man, and, like it, supports the medulla oblongata.

The inferior fossa of the cranium of birds, being considerably narrower than the superior, the body of its lateral parietes is occupied by the cavities of the internal ear.

The differences which exist in birds, with respect to the internal fossæ of their cranium, are very inconsiderable, and consist merely in a greater or less degree of depth. In general, we observe, that their inequality is less in the swimming and wading birds; and that, on the contrary, the parrot kind, and birds of prey, have these inequalities largest.

D. *In Reptiles.*

The general form of the cavity of the cranium of reptiles is oblong, and almost of an equal breadth, being merely a little contracted between the ears. The *tortoise* has a kind of sella turcica, the four clinoid processes of which are directed forward. The sphenoidal fossa is somewhat depressed in the *serpents*, but it has no clinoid processes. It is a semi-lunar depression, the plane of which is situated obliquely from before backward.

The basilar fossa is lower than the other fossæ in the *crocodile*, and in some *tortoises*.

E. *In Fishes.*

We have also very little to state with respect to the inside of the cranium of fishes. As the cavity of their cranium is not completely filled by the brain, its form does not correspond with the eminences of that viscus, and the different depressions we observe within the cranium are not separated by sharp ridges. The base is almost always plain, with the exception of a depression found in some species, and which corresponds by the place it occupies to the basilar fossa, but which is destined to contain the whole of the brain.

The cranium of osseous fishes is enlarged between the ears instead of being contracted, because these organs are contained in the same cavity as the brain. The contrary disposition prevails in the Chondropterygii.

ARTICLE IV.
*Of the Foramina of the Base of the Cranium.*A. *In Man.*

THE base of the cranium is perforated by a great number of holes, which afford passages for
nerves

nerves and vessels. Some communicate with the face, others open into the parts situated posteriorly. The most considerable of the latter is the *foramen magnum occipitale*, through which the medulla oblongata, and the vessels that accompany it, pass. It is situated at the bottom of the cerebellous fossa, immediately below and behind the basilar fossa. Its shape is oval, its greatest diameter is between the fore and back part. Under the anterior of each of its lateral edges, we find one of the prominences by which the head is articulated with the vertebral column, and which are called the *occipital condyles*. The body of each of these condyles is perforated by a small canal, which is directed from within outward, and a little forward and upward, and through which the nerves of the ninth pair are transmitted. This is the *anterior condyloid* foramen, which affords a passage to the nervus hypoglossus major. A little more outward and backward, we observe another small hole, which is sometimes wanting; it is directed backward and downward, and serves for the passage of a small vein. This is called the *posterior condyloid* foramen.

A little farther forward and outward, there is a large hole formed by the posterior edge of the os petrosum and the os occipitis. It is called the *foramen lacerum posterius*. It is situated exactly below an impression formed behind the os petrosum by the great lateral sinus. A groove, made by the inferior petrous sinus, also joins
this

this hole, and it is indeed by it that all the blood of the brain descends into the jugular vein. This hole, at the same time, affords a passage for the *par vagum*, the *glosso-pharyngæus*, and the *nervus accessorius* of the eighth pair. The part which transmits the *glosso-pharyngæus* is frequently separated by a small osseous lamina.

At the posterior surface of the *os petrosum*, a little above the *foramen lacerum*, we find a conical depression directed outward. It penetrates into the interior of the *os petrosum*, where it terminates in two holes, the inferior of which transmits the auditory nerve into the labyrinth of the ear. The other is the orifice of a canal which contains the facial nerve in its passage through the *os petrosum*, and which is terminated between the mastoid and styloid processes by a small hole called *foramen stylo-mastoideum*. The depression we have described is denominated *meatus auditorius internus*.

The cerebellous fossa also exhibits on each side small holes for the passage of the blood-vessels. One is situated in its temporal part behind the mastoid process; its course is very oblique. It corresponds internally with the cavity of the lateral sinus.

Another called *aquæductus COTUNNII*, is situated towards the crest of the *os petrosum*, above and without the *meatus auditorius internus*. It admits some small branches of veins.

In the middle fossæ, we remark the following holes:

The *foramen lacerum anterius*, situated between the point of the os petrosum and the posterior angle of the sella turcica. Its edges are formed by the temporal, the sphenoid, and the occipital bones. It is closed in the fresh state by a cartilaginous substance. There is another hole at its external side, through which the carotid artery enters the cranium, and which is only the opening of a twisted canal, the orifice of which is in the inferior surface of the os petrosum, immediately before the foramen lacerum posterius. This is called the *canalis carotideus*. It transmits, besides the artery, the great sympathetic nerve.

In the inferior surface of the os petrosum, and before the orifice of the carotid canal, we observe the opening of another canal, which communicates with the cavity of the tympanum, and which forms a part of the *Eustachian tube*, or *guttural conduit* of the ear.

In the sphenoid bone, a little before the os petrosum, and without the anterior foramen, there is a large hole, called *foramen ovale*, and which is really of an oval shape. It gives passage to the third branch of the fifth pair of nerves, called *maxillaris inferior*.

A little behind, and without the foramen ovale, there is another hole called *foramen spinale*, through which an artery passes.

Internally,

Internally, with respect to the foramen ovale, and very near the posterior angle of the sella turcica, there is another small hole which transmits a vein.

Still more forward, but not quite so near the sella, we find the *foramen rotundum*, which is directed forward, and transmits the second branch of the fifth pair of nerves, called *maxillaris superior*; it is smaller than the oval foramen.

Under the sharp ridge which separates the anterior fossa from the middle fossæ, there is a long slit which proceeds from the anterior angle of the sella turcica, and extends obliquely outward and forward. It communicates with the bottom of the orbit, and transmits to it the first branch of the fifth pair of nerves, or *ophthalmicus* of *Willis*, and the whole of the *third*, *fourth*, and *sixth* pairs of nerves of the brain, as well as the *internal orbital artery*; this is called the *superior orbital fissure*, or *spheno-orbital fissure*.

The *optic foramina* open into the cranium a little above the anterior edge of the sella turcica, and on the inside of the anterior clinoid processes they are directed obliquely outward into the orbit, to which they convey the *optic nerve* and the *central artery* of the retina.

The numerous holes of the cribriform lamella, of which there are about 40, occupy the bottom of the anterior fossa, and afford a passage for the *olfactory nerves* to the nose.

Before the crista galli, and at its union with
the

the os frontis, we observe a small hole which transmits a vein to the nose. It is called *foramen cæcum*, or *foramen fronto-ethmoidale*.

B. *In other Mammiferous Animals, and in Birds.*

In examining successively the variations which exist in the mammalia and birds, with respect to the principal foramina of the cranium; we shall begin with those situated anteriorly, and shall omit the foramen magnum, which we have already described in the 3d Lecture, when we treated of the articulation of the head; and the foramina of the cribriform lamella, which will be noticed under the article Smelling.

1. *Optic Foramina.*

a. Those foramina are not so far separate in *monkeys*, as in man.

In the *Sarcophaga*, these holes and their intervals are sometimes covered by an osseous lamella, directed from before, backward like a roof.

In some of the *Rodentia*, as the *agouti*, they are separated by only a thin vertical lamina, which is altogether wanting in the *bare*. They are however very much separated in the greater number of the genera.

In the *four-toed ant-eater* the optic foramina are very large, and united at their origin so as

to form a small fossa on the orbital portion of the os sphenoides. In the *armadillo*, and more particularly in the *pangolin*, they are very small. They exhibit no peculiarity in the *sloth*.

The optic holes of the *elephant* arise from a common canal formed upon the body of the os sphenoides, at the origin of which we observe a hole which penetrates that bone. The direction of these holes is oblique; they form a very obtuse angle anteriorly.

They are distinct in the *rhinoceros*, and extend almost directly forward, and form a canal in the body of the bone, of nearly one decimetre in length.

In the *hippopotamus* these holes are very much removed from one another, and they are more oval than round.

Their direction and their respective distance vary in the Ruminantia. In the *chevrotin*, there is only a single optical hole divided by the vomer.

b. The optic foramina of birds, are situated before the small fossa which is placed between their two optic fossæ. They are separated only by the same vertical lamina which divides their orbits.

The part of this lamina which corresponds to them being sometimes notched, as in the *cock*, &c. they there appear to form only one hole, when viewed on the inside of the cranium.

2. *Spheno-orbital Fissure.*

a. The spheno-orbital fissure of *monkeys* is very short, and is even reduced to a simple oval foramen, except in the *orang outang*, in which it resembles that of man.

In the *Sarcophaga* it is always oval, and has the form of a canal.

In the *Rodentia* there is only one hole internally, which supplies the place of both the spheno-orbital fissure, and the foramen rotundum.

In the *two-toed ant-eater* the spheno-orbital fissure, which is very distinct from the optic hole in the inside of the cranium, is confounded with that hole in the orbital and temporal fossa. It is rounded, and before it penetrates the cranium, is indicated by a long furrow or canal in its base: the same structure prevails in the other *ant-eaters* and *armadillos*, as well as in the *sloths*; except that in the latter, the fissure, instead of being rounded within the cranium, has there a triangular form.

In the cranium of the *elephant* this fissure is a large hole rounded internally; it proceeds directly downward into the tempero-orbital fossa, but before it, we observe another hole which is directed horizontally into the body of the bone. These two holes, as well as that of the optic nerve, are covered on the outside by an osseous

lamina, which extends from the superior orbital angle to the most posterior part of the os maxillare superius; so that we observe no hole in the orbit, but merely this large osseous margin.

In the *rhinoceros* the spheno-orbital fissure takes the place of the foramen rotundum; it forms a round canal, the internal opening of which is situated in the sphenoidal fossa, which is very deep. Its external opening is covered by an osseous ridge at the bottom of the temporal fossa.

In the *hippopotamus* this fissure is a simple round hole, of a large diameter.

In the Ruminantia it is also a hole, rounded inferiorly, but truncated and angular superiorly.

In the Solipeda it is intersected throughout its whole length, by an elevated osseous line, which divides it into two distinct holes.

b. There is no spheno-orbital fissure in birds, but its place is supplied by four distinct holes; one is situated above the optic hole, for the nerve of the fourth pair; two behind, very near each other, for that of the third pair; and the ophthalmic branch, of the fifth pair. Lastly, one under the base of the cranium anteriorly, which corresponds on the inside to the basilar fossa, and which serves for a passage to the nerve of the sixth pair.

3. Foramen Rotundum.

- a. The foramen rotundum of the *monkey* is marked,

marked, for a considerable length, before it leaves the cranium, by a furrow on the internal surface of the os sphenoides, near the sella turcica.

In the Sarcophaga it is rather oval than round, and very large.

In the Rodentia it is frequently confounded with the spheno-orbital fissure, as in the *porcupine*, the *cavy*, and the *marmot*.

In the Edentata the round hole is always distinct, and forms a canal of different lengths, according to the genus, within the bone.

In the *elephant* the round foramen is confounded with the spheno-orbital fissure. The same disposition prevails in the *rhinoceros* and the *hippopotamus*; in the Ruminantia and the Solipeda.

b. There is only one hole in birds which occupies the place of the round and oval foramina of man; it exists in the line which separates the optic from the basilar fossa.

4. Foramen Ovale.

In *monkeys* this hole does not perforate the os sphenoides only, but is included between that bone and the os petrosum.

In the Sarcophaga it exists entirely in the os sphenoides. In several genera, as *bears*, *cats*, and the *civet*, the external edge of this hole is

protected by an osseous lamina, which extends along it to the sphenno-orbital fissure.

In the *seal*, the *bear*, the *badger*, and the *rouset*, this hole is wanting, or rather it unites with the foramen rotundum.

Amongst the Rodentia, the *marmot*, the *agouti*, and the *squirrel*, have a distinct oval foramen; but in the *cavy*, and the *porcupine*, it is confounded with the anterior foramen lacerum.

In the *ten-banded armadillo*, and the *four-toed ant-eater*, the oval hole does not exist, or is confounded either with the foramina lacera, which are united, or with the foramen rotundum, which is very large, and of an oblong form.

The foramen ovale is very distinct in the *slotb*.

In the *elephant*, it is confounded with the anterior foramen lacerum, which is very large. It is the same with respect to the *hippopotamus*.

In the Ruminantia, animals which have no anterior foramen lacerum, the ovale foramen is very large.

It does not exist in the Solipeda.

5. Foramen Lacerum Anteriorius.

a. This hole is wanting in *monkeys*, and the *Sarcophaga*. In several of the Rodentia, as the *cavy*, the *porcupine*, and the *marmot*, it is very large: we observe it also in the *agouti* and the *bare*, but it is not found in the *squirrel*.

In the *pangolin* and the *slotbs*, this hole is very small.

small. It is confounded with the posterior foramen lacerum in the *armadillo*.

It is very large, in proportion to the others, in the *elephant*, and very distinct from the carotid canal.

In the *hippopotamus* it is confounded with the posterior foramen lacerum.

It does not exist in the Ruminantia.

In the Solipeda it is confounded with the posterior foramen.

b. Birds have no anterior foramen lacerum.

6. *Canalis Carotideus*.

This canal is similar in *monkies*, and in *man*; but it is much shorter, and less tortuous, in the *Sarcophaga*.

It does not exist in the Rodentia, and the artery passes immediately through the anterior foramen lacerum.

In the *elephant*, it perforates the body of the os petrosum, and terminates at the internal extremity of its anterior angle.

In the *hippopotamus* it is confounded with the foramina lacera.

The same thing takes place in birds.

7. *Foramen Lacerum Posterius*.

a. This foramen exhibits no peculiarity either in *monkies* or the *Sarcophaga*. It is small in

most of the Rodentia; it forms a very round hole in the *pangolin*, and the *shoth*; but the anterior condyloid foramen is very remarkable in these animals, as it is exceedingly large, and situated before the condyle.

In the *elephant*, the posterior foramen lacerum is oval, and very great. This animal has no anterior condyloid foramen.

In the *rhinoceros*, the anterior and posterior foramina lacera are confounded in one large fissure, which surrounds the os petrosum. The anterior condyloid hole is very distinct, and very large: there are even sometimes two foramina on the same side, which unite and form one.

With respect to the Ruminantia, the posterior foramen lacerum, in the *stag*, is a very narrow fissure posteriorly, and round anteriorly; in the *camel* it is contracted before, and circular posteriorly.

b. This foramen, in birds, is a small round hole, situated under and within the external aperture of the ear.

8. *Meatus Auditorius Internus.*

a In the *monkeys* above, and without the meatus auditorius internus, there is another larger depression, which receives a projection of the cerebellum; the bottom of this depression is not perforated. It is wanting in the *orang-outang* and *jocko*.

This

This depression is even deeper in the *Sarcophaga* than in *monkies*.

The meatus auditorius internus of the *elephant*, is covered by a large osseous ridge of the os petrosus, at the point of which it is situated.

In the *rhinoceros*, it is small, oval, and situated in the middle of the petrosus bone. Its greatest diameter extends from before backward.

In the *hippopotamus*, the meatus is situated in the middle of the os petrosus. Its diameter is very large, and its edges form a kind of osseous canopy.

It presents no remarkable peculiarity in the Ruminantia. It is situated in the centre of the os petrosus. Its place is the same in the Solipeda.

b. The meatus auditorius internus of birds, is in general pretty considerable.

C. In Reptiles and Fishes.

The interior part of the cranium is frequently not closed by ossification in reptiles and fishes, and the olfactory nerves pass through a large vacant space, which is not sub-divided into particular holes. This at least is the case with the *camelion*, the *iguana*, *tortoises*, the *pike*, the *anarchichas*, &c. In others, the olfactory hole is contracted, but is still simple, as in the *crocodile*.

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It is double in *frogs* and *salamanders*. The *rays* and the *sharks* have also two holes, which are considerably removed from each other.

The optic holes are likewise sometimes united into one, as in the *crocodile*: those of the *tortoise* are much removed from each other, and are distinguished from the great hole in the front of the cranium, by only a small boney partition. The structure of the cranium in the *pike* is similar. In the *frogs*, the *rays*, the *anarrhichas*, and it should seem, in the greater number of fishes, the optic holes are at a great distance from each other, and perforate the sides of the cranium. These animals have no spheno-orbital fissure, and the small nerves transmitted to the eyes, pass each through a particular foramen.

There is, in general, only one hole on each side for the three branches of the fifth pair of nerves, which, therefore, supplies the place of the foramen rotundum, foramen ovale, and in part of the spheno-orbital fissure. This hole, however, is divided into three in the *carp*.

The meatus auditorius internus exists only in the Reptiles, and the Chondropterygii order of fishes. The other fishes, having the cavity of the ear united with that of the cranium, want this hole.

Fishes have a large foramen for the eighth pair of nerves, which is very considerable; and a small hole beside the foramen magnum, for the
ninth

ninth pair. It must be remarked, that the veins do not pass through this hole, as in the Mammalia and birds.

ARTICLE V.

Of the Bones which compose the Face.

A. In Man.

WE have already observed, that the face is that portion of the head which is situated under the anterior part of the cranium : its form is chiefly determined by the bones of the upper jaw, or *ossa maxillaria superiora* ; we shall commence our description with them.

When the maxillary bones are united, the common base represents a parabola ; it is arched inferiorly, to form the palate, and its circumference contains the alveoli of the teeth. A suture, which extends from its anterior part backward, divides it into two semi-parabolæ. The body of the bones has the same curvature, as it arises from this base ; but it soon enlarges towards the sides, and becomes flattened anteriorly. Its superior part, a proportion of which serves for the lower surface of the orbit, is plain, almost triangular, and inclined forward and outward. The internal edges of the superior surfaces

faces of these two bones, do not come in contact like those of their base: on the contrary, they are very much removed from each other by the nasal fossa, which penetrates the face horizontally from before, backward, between the two ossa maxillaria, and to which the arch of the palate serves as a base. The external angle of the superior surface of each jaw-bone is inclined still more outward than the other parts; this gives to the lateral enlargement of these bones a sharp figure: to this external prominence, which is called the malar process, is articulated the cheek bone (*os malæ*, or *os jugale*), one of the bones by which the face is joined to the cranium.

From the internal and anterior angle of this orbital surface of the *os maxillare*, as well as from the anterior edge of the body of the bone, there arises another apophysis, called the ascending or nasal process, which forms the internal margin of the orbit, and articulates with a corresponding process of the *os frontis*. Between the nasal processes of the two ossa maxillaria, we find the two bones of the nose (*ossa quadrata*, or *ossa nasi*), which form a kind of roof above the entrance of the nasal fossæ: this is one of the points by which the face is attached to the cranium.

The *os ethmoides* is situated between the orbital processes of the maxillary bones. We have already observed, in treating of the cranium, that

that the cribriform lamella of this bone fills up the vacant space of the *os frontis*, between the two arches of the orbits: there descends from each side of the cribriform lamella, a thin plain lamina, which joins the internal edge of the superior surface of the maxillary bone, and thus forms the internal parietes of the orbit. This lamina was formerly called *os planum*: between it and the nasal process of the *os maxillare*, there remains a small space, which is occupied by a thin bone, called *os unguis*, or *lacrymale*.

From what has been observed, respecting the *os ethmoides*, it will appear, that it may be said to form the ceiling of the nasal fossa; this ceiling is very irregular; we shall describe its different laminæ and sinuses when we come to the article Smelling: at present we shall just mention, that there is a vertical lamina extended longitudinally over its middle part, and which, being continued with the *vomer*, by means of a cartilage, divides the cavity of the nares into two portions nearly equal.

This cavity of the nares is extended posteriorly beyond the *ossa maxillaria*; its posterior limits are partly formed by the *os sphenoides*, and partly by the *ossa palati*.

The *os sphenoides* contributes to terminate the cavity of the nares posteriorly, by the means of two processes, which descend almost vertically from each side of its body, between the foramen rotundum, and foramen ovale; these
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are called the *pterygoid*, or wing-like processes ; they are divided posteriorly by a fossa, into two lamina, called the internal and external wings, into which some muscles are inserted.

Between the anterior edge of this process, and the posterior edge of the *os maxillare superius* of the same side, we find the *os palati*, which is a small bone, composed of two laminæ, or principal parts ; one is inferior and horizontal, and is continued with the arch of the palate, of which it forms the posterior border ; the other ascends against the internal parietes of the nasal fossa, passes over the *os maxillare*, and is articulated with the sphenoidal and ethmoidal bones in the bottom of the orbit.

We have thus traced the middle junction of the face with the cranium, by the *os frontis*, *os ethmoides*, and *os sphenoides*. It remains for us to shew how its lateral connection takes place, for which it is only necessary to describe the *os malæ*.

This bone, as we have already observed, is attached to the malar process of the *os maxillare* ; its external surface exhibits four edges :
 1. That by which it joins the before mentioned process, and which forms an oblique future in the front of the face, under the eye : 2. That by which it assists, with the *os frontis*, and *os maxillare*, in completing the anterior frame of the orbit ; it is joined in this part to the *os frontis*, by an ascending process, which corresponds to
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the external orbital process of that bone: behind this process there is a lamina, which extends a little inward and backward. It unites with the orbital process of the os sphenoides, and in concert with it completes the external parietes of the orbit: Lastly, The other two edges of the malar bone are separated by a process called the *zygomatic*, which is connected with one produced from the os temporum, and with it forms a figure like the handle of a vessel, on each side of the head, which is named *zygoma*, or the *zygomatic* or *jugal arch*.

The *zygomatic* process of the os temporum arises a little above and before the meatus auditorius externus, by a double elevated ridge, and forms nearly two thirds of the jugal arch; under its base is situated the glenoid cavity, which serves for the articulation of the lower jaw. We shall shortly notice this last part, to complete our account of the bones which compose the face; it will, however, be described more in detail when we treat of Mastication.

The curvature of the *maxilla inferior* is nearly the same as that of the alveolar edge of the ossa maxillaria superiora. In white men its surface is continued with that of the upper jaw, but in negroes these two surfaces form anteriorly an angle of 70° : its lateral parts are more prolonged posteriorly, and rise towards the zygomatic arch. This ascending branch is nearly square; its superior edge is deeply notched; the

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condyle,

condyle, which serves for its articulation, is situated at the posterior angle. The anterior angle, which is called the coronoid process, is flat and pointed; it affords an attachment to the muscles, which assist in mastication.

B. *In other Mammiferous Animals.*

The shape and size of the face depend chiefly on the form and extent of the bones of the upper and lower jaw.

Quadrupeds have two bones in the jaws, in addition to those of man: they are called *ossa inter-maxillaria*, *ossa incisoria*, or *ossa labialia*, and are situated at the extremity of the mouth, between the *ossa maxillaria*: they contain the *dentures incisores*. This difference, however, between quadrupeds and man, is not in reality of very great importance; for the future which separates these bones from the maxillary, exists also in the human foetus, and is obliterated at a very early period, in some quadrupeds. The skeleton of the *jocko* of the museum, though young, exhibits no trace of this future, but it is very distinct in that of the *orang-outang*.

The face of *monkeys*, in other respects, does not differ from that of man, as to the manner in which it joins the cranium, nor as to the bones of which it is composed. The principal difference as to form, is produced by the great elongation

elongation of their ossa palati, and ossa maxillaria, in proportion to their height; and by the anterior part of those bones being inclined more or less forward, instead of being almost vertical, as in man.

This prolongation of the face varies considerably in the different species: it may be determined by the angle, which its anterior plane forms with its base, or the palate: this angle is more acute in proportion as the face is elongated.

These animals have frequently only one nasal bone, which is very narrow. The *sapajous*, however, have always two: the interval between the orbits is more contracted than in man, and posteriorly it is reduced to a simple partition. It is thus in the *guenons*, and in the *sapajous*. But the *orangs*, the *mdgots*, and the *alouates*, have this interval sufficiently broad to allow the nasal fossæ to ascend into it.

The face of the *Sarcophaga* is distinguished from that of the *Quadrumanæ*; 1st, In having the ascending processes of the ossa maxillaria much broader, which removes the orbits towards the sides; 2dly, Because the orbital surface does not form the inferior, but the anterior parietes of the orbit; 3dly, Because the os malæ neither articulates with the os frontis nor os sphenoides, and only contributes to form the zygomatic arch, and the inferior edge of the orbit; 4thly, Because the orbit is not inclosed

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either posteriorly or inferiorly, and communicates freely with the temporal fossa; 5thly, Because the ossa palati are much elongated, and form a considerable portion of the internal parietes of the orbit, to which the os ethmoides contributes nothing.

The snout also differs with respect to the degree of its elongation; the anterior opening of the nose is truncated more or less obliquely at the extremity.

The os lachrymale advances a little upon the cheek in some species, as the *flying lemur*.

The separation of the orbits is still larger in the Rodentia than in the Sarcophaga; their inter-maxillary bones, which are immense, in consequence of the magnitude of their incisive teeth, throw the ossa maxillaria very far back: the latter form a great part of the internal parietes of the orbit, in which the palate bones occupy only a small space. The anterior parietes are formed by a process of the os maxillare, which assists in composing the zygomatic arch, so that the cheek-bone is suspended in the middle of that arch between the maxillary and temporal processes; it neither joins the os frontis nor the os sphenoides. The elongation of the bones of the nose is such, that the aperture is always situated at the extremity of the snout.

The face of the *elephant* has the greatest resemblance to that of the Rodentia; the magnitude of the inter-maxillary bones, the position
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of the ossa maxillaria, and ossa malarum, and the connections of the latter are similar. The height of the alveoli of the tusks elevates, however, the situation of the nose, and shortens its bones. This circumstance completely changes the physiognomy of the head.

The face of the *slotbs* is very short superiorly, in proportion to the cranium: the ossa maxillaria extend to the internal surface of the orbits: the os malæ is attached to the os maxillare only; it does not join the zygomatic process of the os temporum, and there is a vacant interval between these two bones: the ossa malarum have a long descending process. Though these animals want the incisive teeth, they have two very small ossa inter-maxillaria, which form the inferior margin of the aperture of the nostrils.

In the long-nosed *Edentata* the face has a conical form; the maxillary bones do not extend to the orbit; the os lachrymale, being very large, separates them from it; and the os palati, which is very long, forms alone the lower part of the internal parietes of that fossa. The pterygoid processes are supplied by two laminæ, which are continued with the ossa palati, and which, joining each other inferiorly, prolong the canal of the nares to the foramen magnum. The zygomatic arch is not entirely ossified in the *ant-eaters* and *pangolins*, but it is completed in the *orycteropus*, or *cape ant-eater*, and in the *armadillos*. The situation of the os malæ of

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these animals is almost the same as in the Rodentia.

The form and disposition of the bones of the face in *hogs*, are nearly the same as in the *Sarcophaga*, except that the ossa lachrymalia advance farther upon the cheek. In the *tapir*, the os maxillare is directed backward under the orbit, to which it furnishes a kind of horizontal floor. The bones of the nose do not form an arch, which, with the ossa maxillaria, would inclose the nasal cavity, but only furnish to it a kind of projecting roof, which supports the superior part of the proboscis.

The os maxillare of the *rhinoceros* passes under the orbit, as in the *tapir*; the ossa nasi do not form a continued canal with the maxillary bones, but a kind of suspended arch, which is very thick, and which supports the horn: when there are two horns, the posterior one is supported by the os frontis. The inter-maxillary bone is very small.

The disposition of the ossa nasi is the same in the *hippopotamus* as in the hog; the inter-maxillary bones are very large; the jaw-bones do not form the lower part of the orbits; their anterior portion, which contains the tusks, is directed considerably outward. This circumstance produces that great breadth of the muzzle observed in the hippopotamus. The os malæ has a post-orbital process, which nearly joins that of the os frontis; but it does not unite to the

os sphenoides, and the orbit is not separated from the temporal fossa posteriorly, though its frame is almost complete.

The *daman* (*hyrax*), which should be classed with the Pachydermata, and not with the Rodentia, to which order it has hitherto been referred, resembles the hog in the disposition of the bones of the face: it is only proportionally shorter, and the maxillary bone passes under the orbit, so as to form its inferior parietes, as in the tapir.

The face of the Ruminantia has much resemblance to that of the hog; the inter-maxillary bones are prolonged farther forward, and are not furnished with teeth, except in the camel; the ossa maxillaria form a small part of the floor of the orbit. The os lachrymale is extended considerably forward on the cheek, where it is perforated in different ways, and most remarkably in the *deer*. The post-orbital process of the os malæ unites by a suture to a like process of the os frontis, and thus completes the frame of the orbit; but as it does not touch the os sphenoides, there remains a large communication posteriorly, between the orbit and the temporal fossa.

The face of the Solipeda differs little from that of the Ruminantia, except that it is not joined to the os frontis by an ascending process of the os malæ; on the contrary, a process descends from the os frontis, and joins the body of the os malæ, behind the orbit.

The orbits are always widely separate from each other in the Ruminantia and Solipeda.

The magnitude of the alveoli of the dentes canini greatly enlarge the os maxillare of the *morse*, and give a swollen appearance to the anterior part of the muzzle, but the connection of the bones is nearly the same as in the *Sarcophaga*.

In the *lamantin*, the ossa maxillaria are not much elevated; they form a base to the orbit, and afterwards extend to a considerable distance behind it. That fossa being much advanced, a process of the os frontis, which is extended forward and outward, forms the roof of the orbit, and contributes to inclose the anterior aperture of the nasal fossa, which is very large, and has its plane directed upward. The inter-maxillary bones are very extensive, although the incisive teeth are wanting.

In the Cetacea, the maxillary and inter-maxillary bones are prolonged into a kind of flattened beak, which they divide into four parallel bands, the ossa inter-maxillaria forming the two middle, and the maxillaria the two external bands. The latter only contain the teeth in those genera which are furnished with them. The nasal fossa is perforated vertically in the anterior part of the cranium; the inter-maxillary bones ascend to it, and inclose it anteriorly and on the sides. The ossa maxillaria also ascend so as to cover all the part of the os frontis, which

which forms the arch of the orbit, but they do not enter into that cavity. The ossa nasi are two small tubercles implanted in the os frontis above the aperture of the nares. The os malæ has a styloid form, and is suspended by cartilages below the orbit. The frame of this fossa is completed posteriorly by a process of the os frontis, which descends to join the zygomatic process of the os temporum, but the orbital and temporal fossæ communicate with each other below that process.

C. *In Birds.*

We have already shewn that the os frontis of birds is prolonged above the orbits in a plate more or less thick, more or less narrow, and more or less notched, under which is situated vertically the septum, which separates these two fossæ, and which adheres by its superior edge to the os frontis, and by its posterior to the os sphenoides. The inferior and anterior edges of this septum are free from adhesion, but they articulate with the bone of the bill, as we shall hereafter explain.

The os lachrymale, or os unguis, is articulated to the external and anterior angle of the os frontis. It has two principal processes: one extends from above downward, and forms the anterior margin of the orbit; the other is di-

rected from before backward, and forms the superciliary ridge. The last process is most remarkable in the diurnal birds of prey, in which it is prolonged by an epiphysis, in the form of a plate, and produces a considerable projection above the eye.

In the *ostrich* there is a series of small bones, which continues this arch to the superior edge of the orbit, leaving a vacancy between it and the os frontis. This process is very short, or is even altogether wanting in the *owls*, the *parrots*, the *grallæ*, and the web-footed birds.

The descending process of the os lachrymale is most considerable in the *parrots*; it extends backward to form the inferior margin of the orbit, which is complete in this genus only.

Next to the *parrots* the *ducks* have this process the longest, and the frame of their orbit is almost complete.

The remainder of the face of birds is formed by the bone of the upper mandible, which, in them, represents the ossa maxillaria, inter-maxillaria, nasi and palati of the mammalia; we even sometimes observe sutures corresponding to those which separate these bones in mammiferous animals.

The form of the bone of the mandible is commonly that of the bill itself, to which it serves as the mould or nucleus. It represents more or less accurately the half of a cone or pyramid; the convex surface of which is outward

ward and upward, and the plain or concave surface of which supplies the place of the palate. We shall not here describe the forms and curvatures of different bills. That is one of the objects of natural history; and besides we shall have occasion to return to it when we treat of mastication.

The base of the convex surface of the mandibula is united to the anterior extremity of the os frontis, sometimes by a moveable articulation; and sometimes their parts are folded together, but always in such a manner as may admit some degree of motion, as the osseous lamina at this place is more or less elastic.

The base of the palatine surface of the bill is divided into four branches, which extend backward as they diverge, and which are sometimes articulated, and sometimes intimately united with the bone of the mandible. The two external branches correspond to the zygomatic arches; they are generally thin, and articulate posteriorly to a small bone peculiar to birds, called *os quadratum*, which moves upon the temporal bone before the ear. The two intermediate arches correspond to the pterygoid processes of mammiferous animals. They are almost parallel, are situated under the septum of the orbits, and are not above half the length of the zygomatic arches; but there is a small slender bone at their posterior extremity, which also joins with the *os quadratum*. We shall describe in detail all these parts, and the variations they undergo,

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undergo, when we come to the article of Mastication, as it is on them the mobility of the superior mandible of birds depends. The inferior mandible is articulated to the os quadratum.

D. *In Reptiles.*

In the *crocodile* the face resembles one half of a cone irregularly flattened on its convex surface. It is chiefly formed by two ossa maxillaria, and two ossa nasi, which are situated almost parallel to each other, and two ossa inter-maxillaria, which form the end of the muzzle, and surround the aperture of the nose like a ring.

The bones analogous to the lachrymalia are four in number, two on each side. The os malæ, which is very large, after forming the inferior, and affording a small process to the posterior edge of the orbit, extends directly backward to join the great mastoid protuberance: thus the temporal fossa has no communication outwardly, except by a hole which is smaller than the orbit, and the greater part of which is covered by these bones, as, by an arch.

The nasal fossæ are continued in a long and narrow tube under the foramen magnum. They perforate the ossa palati, and a particular bone which is analogous to the pterygoid processes of the os sphenoides. This bone is situated almost precisely under the cranium, and is enlarged on each

each side until it forms a kind of square and almost horizontal wing. An osseous branch unites it laterally to the os maxillare and os malæ, in such a manner that a large hole is left on each side of the arch of the palate.

In the *camelion* the face is concave superiorly, and bordered by a serrated ridge throughout the whole of its circumference. We observe two holes which communicate with the orbits, and two other oval foramina, which correspond to the incisive holes in the palatine surface. The bones which compose the face are nearly the same as those of the crocodile. The other lizards exhibit still less difference.

The *frog* and the *salamander* have the nasal and inter-maxillary bones very short, and broader than long, which renders their face round anteriorly. The os maxillare is very narrow, and is scarcely contracted in forming the zygomatic arch. The orbits are large, but have no inferior surface, and therefore communicate with the palatine fossa. The ossa palati form the anterior edge of the orbital fossa inferiorly. They resemble portions of a circle. They are furnished with pointed teeth on their circumference. The canal of the nares is very short in the *salamander*. There is only a simple hole in the *frog*.

The face of the *Surinam toad* is very flat, but the bones are the same as in the frog. The orbital

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bitar fossæ are oval, and no aperture similar to the canal of the nares can be distinguished.

The face of *serpents* is rounded nearly in the same manner as that of the lizards. Between the os frontis and os parietale, there is a particular bone which terminates the frame of the orbit posteriorly. These animals have no os malæ. We can, however, easily distinguish two ossa nasi, two ossa maxillaria superiora, two ossa inter-maxillaria, and some bones analogous to the palatine arches of birds, which are furnished with teeth, and which are articulated to the bone which supplies the place of the os quadratum, with respect to the lower jaw. Two particular bones unites these arches to the maxillaria superiora.

In those that have teeth or poisonous hooks, as the *viper*, the *rattlesnake*, &c. there are besides two small peculiar bones, articulated and moveable, which support those teeth. They are situated upon the inter-maxillary bones and the anterior extremity of the osseous branch which joins the superior maxillary bone to the arch of the palate.

The face of the *tortoise* is circular before, and rounded on every side. It is composed of nearly the same bones as that of the crocodile. The inter-maxillary bones are, at a very early period, consolidated with those of the upper jaw. The bones analogous to the os malæ are three in number;

number; one articulates with the *os temporum* and with the two others; it is situated posteriorly, and forms the zygomatic arch. The other two portions are received on its anterior extremity; one extends upwards, and unites with the orbital angle of the *os frontis*; the other is directed downward, and articulates with the posterior and external process of the *os maxillare superius*.

The *ossa palati* are broad, and form the posterior arch of the nasal fossæ.

The bones of the face of tortoises commonly cover each other at their edges, which are refined into thin laminæ. It is therefore very difficult to distinguish the futures.

In the *sea tortoises* the temporal fossæ, which are very deep, are covered by an osseous lamina, which forms a very solid arch above them.

E. In Fishes.

Fishes, like birds, have commonly a septum or vertical lamina between the orbits, which proceeds from the base of the cranium. This lamina is very remarkable in the *anarrhichas*, which has it entirely osseous. In the greater number of other fishes it is membraneous, and supported inferiorly by an osseous canaliculated stalk, which is directed towards the end of the mouth, where it is enlarged, and to which it is ossified. This bone

bone resembles the vomer. It is greatly elongated in the *whiting*, the *turbot*, &c.

The ossa palati, which are small, receive the anterior extremity of the vomer. They are furnished with teeth in a great number of fishes. The form and disposition of these teeth vary considerably, as will appear when we treat of Mastication.

Two bones, and even sometimes four, proceed from the anterior and superior parts of the cranium to the anterior extremity of the vomer. They represent the ossa nasi. They cover the olfactory nerves; a small interval is left between them in the *silurus galeatus*.

As in birds, there is on each side of the cranium a large moveable bone, to which the lower jaw and the arches of the palate are attached, but in fishes it also supports the operculum of the branchiæ. It is not square as in birds; it is elongated, flattened, and bent lengthways, so as to present its concave edge anteriorly, and its convex edge posteriorly towards the branchiæ. This bone is exceeding large in the *pleuronestes*. It has some accessory laminæ in the *perch*, the *pike*, and a number of other fishes.

The arches of the palate appear to form part of the ossa maxillaria superiora. They are articulated to the bones which support the lower jaw; they are frequently flattened, and project from the lateral parts of the mouth, as in the
dory,

dory, the *whiting*, the *herring*, &c.: they are cylindrical towards the middle, flat posteriorly, furnished with teeth in the front, and situated in the centre of the mouth, in the *sea-wolf*, or *anarrhichas*.

The zygomatic arches are situated obliquely; they descend from before backward, between the extremity of the snout, behind the inter-maxillary bones, and the middle or posterior portion of the lower jaw; their posterior extremity frequently does not extend to the bone analogous to the os quadratum of birds: when this is the case, it remains free in the flesh, as in the *herring*, the *pike*, the *perch*, the *sea-dragon*, and some *pleuronectes*, as the *plaice* and the *sole*. These zygomatic arches never extend to the teeth.

Two bones, commonly furnished with teeth, are situated before the anterior extremities of the arches; they may be regarded as inter-maxillary bones; they form the anterior part of the snout; they are very large and solid in the *anarrhichas*; narrow, and much elongated posteriorly, in the *whiting*, the *perch*, and the *sea-dragon*; short, triangular, and flat in the *pike*, and the *chaetodons*; that on the side, which does not contain the eyes, is considerably more developed in the *pleuronectes*.

Besides the anterior and posterior orbital processes which form the anterior part of the cranium, there is a bone, or rather a series of small

bones, situated under the orbit, which completes the frame of that cavity; these bones appear analogous to the os lachrymale: they are wanting in the false orbit which we observe on one side of the head of the *pleuronectes*.

The face of the Chondropterygii, though similar in its composition to that of other fishes, differs from them with respect to its connection, as it is articulated with the cranium only, by the means of the bone analogous to the os quadratum of birds.

ARTICLE VI.

Of the Fossæ of the Face.

A. In Man.

A FRONT view of the face exhibits three principal fossæ; the nose and the two orbits.

The anterior aperture of the nose is oval, and notched in the middle by a small spine; it is bounded by four bones, the two superior maxillary, and the two nasal. The interior of this fossa will be described more in detail when we come to the article Smelling.

The orbits are two fossæ, the margin of which is irregularly rounded, and almost rhomboidal; they are contracted into the form of a funnel;

the edges of their aperture are nearly in the same plane. Three bones contribute to the formation of these edges, the os frontis, the os maxillare, and the os malæ. Seven bones form their parietes, viz. the frontal, ethmoid, lachrymal, palatine, maxillary, malar, and sphenoid: their internal, external, and inferior parietes are almost plain; the superior is concave, the internal or nasal parietes of the two orbits are parallel to each other; the internal side forms, with the external, an angle of about 45° ; and the axes of the two orbits form an angle of similar magnitude.

On viewing the face laterally, there appears a large depression, situated behind the orbit. It is called the temporal fossa; a considerable portion of it is impressed on the cranium. The zygomatic arch extends like a bridge over this fossa, which becomes deeper as it descends before—it is most hollowed at the posterior surface of the superior maxillary bone, and the adjacent portion of the os sphenoides. The part which is opposite to the zygoma is called the zygomatic fossa; some muscles are lodged in it. When the face is viewed inferiorly, this fossa is also seen.

In this last view of the face, we also perceive the palatine fossa, or arch of the palate, encircled on the front, and on the sides, by the teeth:—the posterior extremity of the nasal fossæ, and at their side the *pterygoid fossæ*, situ-

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ated between the two processes of that name, which belong to the os sphenoides.—Lastly, all the space included between the foramen magnum, and the posterior margin of the palate, which is called the *guttural fossa*.

B. *In other Animals.*

We shall proceed to consider each fossa of the face separately, in all the classes of animals.

1. *Nasal Fossæ.*

a. The anterior aperture of the nasal fossa in the *jocko*, is, as in man, broadest inferiorly.

In the *orang-outang*, the *sapajous*, the *alouates*, and some *guenons*, it is oval, and is broadest in its middle part. In other *guenons*, as the *Chinese monkey*, &c. in the *Barbary ape*, and the *mandrils*, it is broadest towards the upper part. In all these animals this aperture is flattened down upon the face, and surrounded by four bones only, viz. the ossa nasi, and the ossa inter-maxillaria.

In the *Sarcophaga*, this aperture approaches nearer to the end of the snout; its form is nearly round, but broadest towards the upper part; it is inclined more backward in the *seal*, than in the other genera.

In the *Rodentia*, it cuts the end of the muzzle

zle vertically ; its form is that of a heart, with the broadest side uppermost.

This form is nearly similar in the *Edentata*. In the *slotbs*, however, the aperture of the nostrils is surrounded by six bones, viz. the inter-maxillary, maxillary, and the nasal. In the *ant-eaters*, this fossa is extended towards the foramen magnum.

The nasal fossæ of the *elephant* open at nearly an equal distance between the summit of the head, and the edge of the alveoli ; their breadth considerably exceeds their height, and their form resembles that of two ovals joined together.

In the *Pachydermata* the ossa nasi of the *hog* form a pointed projection over the aperture of the nasal fossæ. Between their point, and the corresponding part of the ossa inter-maxillaria, there are two small peculiar bones, which serve to strengthen the snout, called *the bones of the snout*. In the *rhinoceros*, and particularly in the *tapir*, the aperture of the nares is considerably longer ; the ossa nasi advance upon it beyond its anterior extremity in the *rhinoceros*, but only one third of its length in the *tapir* : in both it is surrounded by six bones. In the *hippopotamus* the aperture of the nose is very broad, and situated vertically at the end of the muzzle.

In the *Ruminantia* this aperture is very large, and inclined backward. The ossa nasi form only a short serrated projection in the *ox*, the *deer*, the *camel*, and the *musk*. The projection is

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pointed in the *antelopes*, the *sheep*, and the *goats*.

In the *morse* this projection is long and pointed.

The *morse* has a small round aperture in the middle of the end of his thick snout; the *dugon* and the *lamantin* have a large oval aperture directed upward; their ossa nasi are very small.

In the Cetacea the aperture of the nares is directed upward, or even backward; it is more broad than long, and surrounded by six bones; the ossa nasi are small tubercles.

b. The nasal fossæ of birds do not form a canal passing from before backward, but merely a cavity which occupies the thickest part of the base of the bill, and which opens upward by two nares, and downward by a fissure, leaving between them the two palatine arches: it is not separated from the orbit posteriorly by an osseous lamina, but by a membrane.

The external aperture of the nares is formed in the base of the convex surface of the bill. Its figure and magnitude, which vary considerably, shall be described when we treat of the Organ of Smell.

c. The nasal fossa of *tortoises* forms a large space occupying the thick part of the nose before the eyes; it is very short from before backward; it opens outwardly by a large hole almost square, the plane of which is a little inclined, and posteriorly by two round holes, which correspond

nearly to the middle of the palate ; its anterior aperture is surrounded by six bones.

In the *crocodile* the nasal fossa is a long narrow canal, which extends from the end of the snout to below the occiput ; its anterior aperture is directed upward ; it is surrounded by the two ossa inter-maxillaria only.

The nares in other *lizards* open nearly in the same manner as those in birds, that is to say, outwardly upon the nose, and inwardly on the middle of the palate. In *frogs* they are still shorter.

d. The nasal fossæ of *rays* and *sharks*, are simple cavities formed in the bone, and do not communicate with the mouth ; it is the same in several osseous fishes, such as the *gurnards* ; but in most of the other fishes these fossæ are in part osseous, and completed by membranes.

2. Orbital Fossæ.

a. All the *monkey* tribe have their orbits directed forward, as in man, and the angle formed by their axes is even smaller than in the human cranium. The form of these cavities, and the bones which surround them, exhibit no difference, but the shape of their margins vary. In the *jocko* they are similar to those in man. The *orang-outang* and the *sapajous* have them of an oval form, always higher than broad. In the *guenons*, the superior arch is less curved than

the rest of the margin, which produces a conspicuous angle on the side of the nose; the breadth of their fossæ exceeds their height: this difference is still greater in the Barbary ape.

The angle formed by the axes of the orbits, enlarges in the other animals, as we have already remarked. The margins of the orbital fossæ are nearly round in the Sarcophaga, the Rodentia, the Edentata, and the Pachydermata; but posteriorly there is always an arch which is not inclosed by the bones; there is also no partition between the orbit and the temporal fossa. In treating of the face, we have already pointed out the differences which prevail in the number and kind of the bones that contribute to form this fossa.

The Ruminantia and the Solipeda have a round orbit, the margin of which is complete, but it is not separated from the temporal fossa.

The roof of the orbit of the Cetacea is semicircular; their two axes are in the same right line: they have no inferior parietes.

b. The orbital fossæ of birds are similar to the impressions which might be produced by two fingers pinching the cranium in a soft state; they have no osseous parietes inferiorly: the lamina which separates the orbits is only partially ossified, and the portion which continues membranous is even very large in some birds; but there is nothing uniform in this respect.

c. The orbital fossæ of reptiles are never separated

parated from the temporal fossæ, except by an osseous branch, which even is not complete in the *lizards* and the *tortoises*, and which does not exist at all in *frogs*, *salamanders*, and *serpents*.

The plane of the edges of the orbit is lateral in *tortoises*, *serpents*, and the *camelion*: it is directed more or less upward in the *crocodiles*, *salamanders*, and *frogs*.

It varies from a circular to a triangular form.

The inferior parietes is never complete; it is sometimes entirely wanting; at other times it is perforated by a large hole. The same observation applies to the septum between the orbits.

d. The orbital fossa of fishes varies considerably with respect to its shape, its direction, and the composition of the bones that form its edges. It is lateral in the greater number, but is directed upward in some, as in the *star-gazer*, and several others. The *pleuronectes* have only one perfect orbital fossa. We can, with difficulty, discover the second in their skeleton; because it is placed on the same side with the other, and is exceedingly small and deformed.

The inferior margin of the orbital fossa is formed, in some fishes, by a continued piece analogous to the os malæ; and in the others, by a series of small bones, suspended by ligaments articulated to each other. There are frequently five of these bones.

There is never any osseous separation between

the orbits and the temporal and palatine fossæ.

3. *Temporal Fossæ.*

a. The extent of the temporal fossa depends on the magnitude of the space depressed on the side of the cranium, and of the external convexity of the zygomatic arch; this fossa is entirely occupied by the temporal muscle which raises the lower jaw. It appears, however, more proper to refer our account of this fossa to the article on Mastication.

To the same article we shall also refer the consideration of the palatine pterygoid, and guttural fossæ.

ARTICLE VII.

Of the Holes of the Face.

A. *In Man.*

THE orbital fossa communicates with the interior of the cranium, by the *optic foramen*, and by the *spheno-orbital fissure*, of which we have already treated; it communicates with the deep portion of the temporal fossa, by the *spheno-maxillary fissure*, extending between the orbital process of the os sphenoides, and the orbital surface

surface of the os maxillare, which are not united. Part of the fifth pair of nerves passes through this fissure, as it proceeds from the orbit into the temporal fossa. The communication of the orbitar with the nasal fossa takes place, first, by one or two small holes, situated sometimes in the os frontis, and sometimes in the suture, by which it joins the os planum; these are called the anterior *internal orbitar foramina*; they afford a passage to the nasal nerve, which proceeds from the ophthalmic branch of the fifth pair. Secondly, it communicates with the nose by the *lachrymal canal*, which passes along the inner margin of this fossa, and is situated partly in the ascending process of the os maxillare, and partly in the os lachrymale; it descends almost vertically into the nose.

The spheno-maxillary fissure is prolonged a little as it descends into the temporal fossæ. In its deepest part is found the *spheno-palatine* hole, which is formed by a groove in that part of the palate bone which joins with the body of the os sphenoides; it extends partly into the nose, and assists in forming the orifice of a small conduit, which descends between the os palati and the pterygoid process, and which opens towards the posterior angle of the arch of the palate, by a hole called *foramen gustatorium*, or *posterior gustatory hole*; it affords a passage to a small ramification of the fifth pair of nerves, in its course towards the superior maxillary branch.

There

There is also in the middle future of the arch of the palate, and immediately behind the *dentes incisores*, a single hole, called *foramen incisivum*. Some branches of the superior maxillary nerve pass through this hole.

Lastly, we observe in the front of the face, and under the orbit, another hole, called the *sub-orbital foramen*. It serves as the outlet of a small canal, which passes under the floor of the orbit, and gives exit to the last branches of the superior maxillary nerve. We also remark a much smaller hole above the orbit, which is sometimes merely a notch; it is called the *superciliary foramen*, and transmits the frontal branch of the ophthalmic nerve.

B. *In other Animals.*

We shall consider the principal holes of the face as they appear in the different classes of animals.

The lachrymal canal we shall omit till we have occasion to treat of the Eye.

1. *Spheno-maxillary Fissure.*

The spheno-maxillary fissure of the *monkey* kind is much shorter than that of man; it is reduced to a simple hole in some *sapajous*. It is entirely closed in the *alouate*; it is partly supplied

plied by a hole in the cranium, situated behind the orbit, at the deepest part of the zygomatic fossa, and probably also by a pretty large round hole situated in the os malæ.

The animals that have no partition between the orbit and the temporal fossa, have also no spheno-temporal fissure; the latter, therefore, does not exist in any of the mammalia, except the *Quadrumana*, nor in any of the other classes.

2. *Internal Orbital Foramina.*

The anterior and posterior internal orbital foramina, are very small in the *monkeys*; the latter is even often wanting; when it exists, it passes through the os frontis.

In the *Sarcophaga*, the anterior foramen is very large, and situated at the inferior part of the orbit in the os maxillare: the posterior foramen terminates in the cranium by an aperture, situated behind and above the cribriform lamella.

In the *Rodentia*, the anterior foramen resembles that of the *Sarcophaga*; the posterior is smaller, and situated entirely behind the cribriform lamella.

In the *Edentata*, the anterior internal orbital foramen is situated altogether in the lower part of the orbit, and perforates the os palati: the posterior foramen, on the contrary, is situated
above,

above, and somewhat before the orbit, in the body of the os frontis.

In the *elephant* the two internal orbital foramina are formed in the os frontis; the anterior somewhat before the orbital fissure, and the posterior under the osseous ridge which covers that fissure; the aperture of the latter, in the cranium, is situated behind, and a little above the cribriform lamella.

It is nearly the same with respect to the other *Pachydermata*.

In the *Ruminantia* and *Solipeda*, the anterior internal orbital hole is very large, and perforated below and before the orbit, between the os palati and the os sphenoides: the posterior is also considerable; it is directed towards the side, and behind the cribriform lamella.

It is very difficult to trace these holes in the *Cetacea*, because they are covered with osseous laminæ, and are very small.

The internal orbital foramina do not exist in the other classes of animals.

3. *Foramen Incisorium.*

a. In all the *mammalia*, the foramen incisorium belongs to the inter-maxillary bones; it is small and single in the *jacko* and the *orang outang*; but it is somewhat enlarged in the other monkeys, and in the *Sarcophaga* it is double.

In the *Rodentia* the *bares* have it very large,
even

even exceeding the solid part of the palate; it is smaller in the other genera; it occupies nearly the middle space between the incisor and the malar teeth.

The Edentata, which have very small intermaxillary bones, have also the foramen incisorium small, and situated near the end of the muzzle.

It is single and elongated in the *tapir* and the *rhinoceros*. In the *elephant* its place is supplied by a long narrow canal.

In the Ruminantia it is exceedingly large; it is oval, double, and situated quite at the end of the snout.

It is nearly similar, but less in *horses* and *hogs*. In the horse there is a single round hole, situated before the two incisive holes.

It is almost obliterated in the *morfe*; small, and much removed from the edge of the alveoli in the *dugon*; single, oval, large, and situated close at the end of the snout in the *lamantin*.

The Cetacea have no foramen incisorium.

b. In some birds, as the *heron*, the *flamingo*, the *eagle*, &c. the incisive foramina are small and numerous; there is only one of a middle size, and situated towards the base of the bill, in the *duck*, the *curassow*, the *cormorant*, the *spoon-bill*, &c. The *casowary* has a small foramen situated towards the point of the bill. The *owls* and the *cocks* have it pretty large. It is of a very great size in the *ostrich*.

c. The

c. The foramen incisorium of the *crocodile* is considerable ; as is likewise that of the *frog* and the *salamander*. The *tortoise* has two very small foramina. We have not been able to discover them in the other *lizards*.

d. There can be no foramen incisorium in fishes, as no part of their face can, with propriety, be called the nasal cavity.

4. Sub-orbital Foramen.

The sub-orbital foramen is single only in the *jocko*. There are two small foramina in the *orang-outang*, and the *sapajous*; three in the greater number of *guenons* and *magots*; four or five in the *macaques* and *mandrils*; the *lemurs* have but one.

There is also only one in the *Sarcophaga*; it is pretty large, and should rather be named the *ante* or *præ-orbital* foramen: it is situated farther forward in *dogs* than in the other genera.

In the *Rodentia* it is simple, and exceedingly large. In the *cavys*, the *agoutis*, the *porcupines*, the *rats*, and particularly in the *jerboas*, it almost equals the orbit in size. It is formed in the malar process of the maxillary bone.

In the other genera of *Rodentia*, as the *bears*, *beavers*, *squirrels*, and *marmots*, it is small, and situated upon, or even before the first *dentes molares*.

It is simple and small in the *sloths*, but in the
long-

long-nosed Edentata, it forms a canal in the base of the malar process of the os maxillare.

In the *elephant* it is of a considerable size, and opens on the lower part of the malar process.

In the other Pachydermata it is nearly the same as in the *dog*.

It is the same in the Ruminantia and Solipeda.

The *seals*, the *morse*, and the *lamantins*, have it situated in the base of the malar process.

There are three or four of these foramina in the Cetacea, situated in a longitudinal line; one of them is even perforated in the inter-maxillary bone; those that are superior have a retrograde direction. The position of the os maxillare in these animals places the foramina above the orbit, instead of below it.

There are no sub-orbital foramina in birds, or in the other classes, as the mammalia alone have lips.

5. *Spheno-palatine Canal.*

The spheno-palatine canal of *apes* does not differ from that of man.

But in all animals, in which the temporal fossa is not separated from the orbital, we easily distinguish a superior aperture situated in the lower and fore part of the temporal fossa. It receives two canals, one of which extends to
the

the nose, and the other to the palate; the latter is sometimes very short, and has often two or three openings into the palate. It is almost horizontal in the Cetacea.

There is none in birds. We find it, however, in reptiles; not indeed in the form of a canal, but as a simple hole in the palatine bone.

LECTURE NINTH.

OF THE BRAIN OF ANIMALS WITH VERTEBRÆ.

ARTICLE I.

Of the Organization of the Nervous System in General.

THE nerves, with the central mass from which they all arise, that is to say the spinal marrow and brain, form the common organ of sensation and volition.

The sensations we experience from the action of external bodies on our own, are more perfect in proportion as the nerves terminating at the part which receives the impression, arise more immediately from the medulla spinalis, and through it from the brain.

If these nerves, however, are tied or cut, all the parts of the body to which they are distributed become insensible, whatever be the distance from the brain at which the section or ligature is made.

In the same manner, if we tie or divide the spinal marrow itself in the neck, the whole body

becomes paralytic and insensible, though the viscera may for a time continue their motions, because they receive a great part of their nerves immediately from the brain. Finally, a general compression of the brain instantly destroys every kind of sensation.

These observations have produced the opinion that there exists a *sensorium commune*, or centre of sensation, to which the impressions of all the nerves are transmitted; and this common organ is supposed to be the brain.

There are, however, several animals in which this union of the branches of the nerves, with their common trunk, is not necessary to sensation. We may, for example, completely remove the brain of a tortoise or a frog, and these animals will still seem to shew by their motions that they possess sensation and volition.

There are also insects and worms, which, when cut into two or several pieces, form immediately two or several individuals, having each a system of sensation and volition. It is only in the animals which are the most perfect, and which approach nearest to man, that the connection of the different parts of the nervous system, and particularly the presence of its central parts, is absolutely necessary to the existence of its functions.

The necessity of this connection increases in proportion to the magnitude of the common trunk, compared with its ramifications. The
more

more equally the medullary mass is distributed, the less essential is the existence of central parts: animals which have this sensitive substance diffused over the whole body, as is the case in *polyps*, may be divided and subdivided to any degree of minuteness, yet each fragment will be endowed with a particular *self-existence*, and become a separate and perfect individual of its kind.

From these observations, it may be conjectured, that the parts of the nervous system are homogeneous, and susceptible of a certain number of similar functions, in the same manner as the fragments broken from a large magnet, become each a smaller magnet, having its poles and motion; and that in the higher orders of animals the connexion of parts is rendered necessary only by accessory circumstances, and the complication of the functions they have to perform, which is also the reason that each part answers a particular use.

With respect to the last fact, it indeed appears that the appropriation of certain nerves to the acquirement of determined sensations, and of others to the performance of particular functions, is the effect of the nature of the external organs, in which the former terminate; and the number of blood vessels which the latter receive at their divisions and unions: in a word, it is rather to be ascribed to any accessory

circumstance, than to the peculiar nature of the nerves themselves.

We shall render the truth of this observation more apparent, by proceeding to consider the general *distribution* of the nervous system, and the nature of its substance.

With respect to the *distribution*, we find that, in all animals which have distinct nerves, these nerves arise from one common mass, which most frequently is of a cord-like figure, and called the *spinal marrow*; the anterior extremity of this medullary rope is always more or less enlarged, and exhibits several tubercles or eminences, which, in animals that have vertebræ, are situated in the head, and have obtained the common name of *brain*.

There are animals, as some Molusca, in which we discover only a simple medullary mass without any cord-like prolongation.

The nerves arise by pairs from the common trunk, or from the mass which supplies its place, and ramify like the branches of a tree as they proceed to the parts they are destined to animate.

Some of these nerves have a simple origin; but the greater part arise or proceed from the trunk in several filaments, which afterwards unite and form one common fasciculus.

The principal branches of the nerves do not always continue to subdivide: on the contrary, it

it frequently happens that several branches, whether belonging to the same or different nerves, unite and separate again in various manners to form plexus, from which new trunks of nerves arise.

Neither do the ramifications always diminish in thickness, in proportion as they divide. We very often meet with a branch which is thicker than that from which it proceeds.

It is even obvious, that the nerves must increase in magnitude as they advance towards the extremities; for the skin, which is sensible in every part, and which consequently is every where furnished with nerves, has several hundred times more superficial extent than all the roots of the nerves taken together.

Communications are established between a great number of very different nerves, by cords which extend from the one to the other: where these communications take place, there is almost always an enlargement or small mass of medullary matter, which seems to be only a very compact plexus, and which is called a *ganglion*.

Filaments, proceeding from several nerves, very often unite into one ganglion, from which other filaments arise, and are transmitted to different parts.

Sometimes also a single nerve swells into a ganglion, and is afterwards contracted.

From this summary description, it appears

that the comparison of the nervous system to the trunk of a tree and its branches is not perfectly accurate; it should rather be considered as a kind of complicated net-work, in which the greater part of the threads communicate with each other, and in which there appear, at different places, masses or enlargements, more or less conspicuous, which may be considered as centers of communication.

The middle part of this net-work always preserves the greatest size, the most immediate connexion, and the most powerful influence with respect to all the other parts.

But the degrees of this influence vary as much as those of its proportional magnitude.

In the animals of the higher classes, the size of the medulla spinalis vastly exceeds that of the nerves which proceed from it, and the brain also greatly surpasses in size the spinal marrow.

These two circumstances are more remarkable in man than in any other animal. His brain is the largest of all, in proportion to the rest of the nervous system. In the other warm-blooded animals, the volume of the brain diminishes in proportion as the spinal marrow becomes larger. In the molusca there is only a brain, from which the nerves proceed like radii, and form scattered ganglia almost as large as the brain itself. In insects, the brain is not larger than each of the numerous ganglia of the spinal marrow, and the nerves arise from both in the same manner:
thus,

thus, in proportion as we descend in the scale of animals, we find the medullary substance less concentrated in a particular region of the system, and more equally distributed to all the parts.

The *texture* of the nervous system may be considered in the brain, in the medulla oblongata, in the medulla spinalis, in the nerves, and in the ganglia.

The brain of animals that have red blood and vertebræ, consists of a mass varying in solidity and firmness, easily divided or compressed, and slightly viscous. We observe in it two principal substances, the *cortical* and the *medullary*; and two others less extensive, which are called the *soft* and the *black* substances. The brain of cold-blooded animals is softer than that of the warm-blooded. Some fishes have the brain almost fluid.

The *cortical* substance is reddish, and semi-transparent; it appears homogeneous to the eye. Injections, however, penetrate its substance to a certain extent, and shew that it is chiefly composed of blood-vessels. Its position, with respect to the medullary substance, varies in the different parts of the brain; but in the circumference of the hemispheres, and of the cerebellum, it is external. Hence it has received its name. The limits of these two substances are very distinct. They do not change by degrees into each other. The cortical substance possesses no sensibility. Its quantity, with respect to the rest of the brain, decreases in the cold-

blooded animals. It is proportionally greater in man than in other animals.

The *medullary* substance is white, opaque, and firmer than the cortical. It appears to the eye composed of very fine fibres, the directions of which are various. Few vessels are observed in it, and injections do not pervade its intimate structure. This substance forms the greater part of the interior of the brain; and the medulla oblongata, and medulla spinalis, are its prolongations. Their texture is altogether similar to that of the medullary part of the brain. We observe in them the same fibrous appearance, mixed internally with a small quantity of cineritious substance.

The *soft* substance is greyish, semi-transparent, and almost fluid. In some parts it covers the surface of the brain. The *black*, or *blackish* substance, colours the medullary part of the brain in two places.

The medullary and cortical substances of white-blooded animals present no difference as to colour, and it is even with some difficulty that we discover any in their consistence. The Crustacea and the insects only have a kind of spinal marrow. It is composed of a double medullary cord, united at different spaces by ganglia. Perhaps it should rather be regarded as a kind of great sympathetic nerve.

The texture of the nerves ought to be considered in their course, at their cerebral extremity

mity or origin, and at their termination in the different parts of the body.

The nerves are not merely enveloped by membranes, which appear to be continuations of those that surround the brain. The membrane to which some modern anatomists have given the name of *neurilema*, (*nerve-tunic*), penetrates also into the interior, and forms septa, which divide the medullary filaments from each other. The medullary substance may be dissolved by alkaline lixivia, and there will remain only the tubes formed by the neurilema. The latter may also be dissolved by acids; we then observe that the medullary filaments, which still remain, anastomose together in various ways. The nerves receive a considerable quantity of blood, which is transmitted to their substance by the vessels of the neurilema, in the same manner as the blood is conveyed to the brain by the vessels of the pia mater.

The term *origin of the nerves* is applied to that part of them which is nearest the brain or medulla spinalis, before it has entered the sheath furnished by the dura mater.

Some nerves appear to derive the medullary fibres, of which they are composed, from the surface of certain parts of the brain. Such in particular are the olfactory and optic nerves in all red-blooded animals, and the auditory nerve in mammalia and birds. Others seem to come from the internal substance of the brain, into
which

which their roots may be traced like those of a tree into the earth. This is most remarkable in the third pair of nerves in the mammalia; but the greater part of the nerves arise by filaments, which are connected to the medulla oblongata, or medulla spinalis, and which unite to form nervous trunks. This, at least, is the disposition which prevails in all animals that have red blood, with respect to the nerves that succeed the auditory, that is to say, reckoning from the *par vagum*.

It is probable that all the nerves penetrate more deeply into the substance of the brain and medulla than it is possible for us to trace them. It is even supposed that they cross each other, so that those which proceed to the left side of the body arise in the right side of the brain; and that those transmitted to the right of the body come from the left of the brain. It is certain that wounds received on one side of the brain have frequently produced a paralysis on the opposite side of the body. We can also clearly perceive the decussation of the optic nerves of fishes, and we conclude that the same thing takes place in other animals, as one of the nerves frequently diminishes in size above and below the place where they are confounded in crossing.

The fibres that compose the medulla spinalis seem also to cross each other in the groove by which it is divided.

In animals that have white blood, the nerves proceed from the brain or the other ganglia; but they never arise immediately from the spinal marrow. Their fibres, however, cannot be distinguished either in these ganglia or the tubercles.

The *termination of the nerves* is different, according to the parts to which they are transmitted. Those which are distributed internally, are accompanied by the neurilema to their most imperceptible extremities. The optic nerve is terminated by a nervous expansion which spreads over the interior of the eye. The acoustic terminates by filaments which swim in a gelatinous fluid. The nerves that belong to the organ of taste are dilated in the nervous papillæ of the tongue; those of feeling terminate in the papillæ of the skin, &c.

The ganglia of red-blooded animals do not appear to differ from *nervous plexus*, except that the filaments which compose them are more compact, and more intimately united. Even the simple ganglia, that is to say, those that are formed by a single nerve, are resolved, by maceration, into several filaments, which anastomose together.

It is the same with respect to the Molusca; but in the Crustacea, the Insects, and the Worms, the ganglia are merely homogeneous enlargements of the medullary cord to which they belong.

From what has been said, it is obvious, that
we

we have but a very limited knowledge of the real texture of this medullary substance which forms the essential part of the nervous system. Is it merely an accumulation of excretory vessels? Is it a kind of gland or parenchyma? Or is it simply a homogeneous mass? Each of these opinions has its partizans and its adversaries.

The chemical nature of this medullary substance is also imperfectly known to us. It is certain, however, that it differs essentially from all other animal matter. It is soluble in caustic alkali, and partly in oil: it is not fat: and yields no oil by expression. It dilutes, but does not dissolve in water; alcohol extracts from it, when warm, a substance, which in cooling precipitates into needles or small laminæ. This matter may be compressed or extended between the fingers. It softens a little at the heat of boiling water, becomes black at a greater heat, and burns without fusing, emitting the same odour, and leaving the same carbon as other animal substances. The medullary part of the nerves presents the same chemical results as the medullary part of the brain.

ARTICLE II.

Of the Nervous System considered in Action.

THE nervous system is susceptible of two kinds of action; one which is confined to our sensitive faculty; and another which affects our vital and vegetative functions only. Voluntary motions and sensations belong to the first of these actions; the influence of the nerves on digestion, circulation, and secretion, to the second. The sympathies and physical changes which are the consequence of certain ideas, or of certain passions, seem to participate in the effect of both.

Sensations may be divided into *external*, *internal*, and *spontaneous*. The first are produced by the impressions of external bodies on our senses. The second by changes which take place in the state of the internal parts of the body, to which the nerves are distributed. The third resemble both the former as to effect; but they are caused by a change in the nerves, or in the brain itself, without any external excitement. The sensations we experience in dreams are similar to those produced in us by external bodies: they originate, however, from motions produced in the brain by internal causes, and may be excited or allayed by certain medicines.

Men who have lost their eyes frequently dream that they see; those who have had their limbs amputated, imagine sometimes, even when awake, that they experience pains in the absent members.

These kind of sensations tend to throw a light on the nature of others. They confirm what sections and ligatures of nerves had already shewn; that sensation does not reside in the external organs, but merely in the centre of the nervous system, and that the external organs serve only to receive the action of external bodies, and to convey it to the nerves, by which it is propagated to a greater distance.

They also farther demonstrate, that this propagation is not produced by any matter or concussion, which external bodies could alone communicate, but by a change in the state of the nervous substance, which may arise from internal causes.

This change may also be produced by external causes altogether different from those which usually occasion it. A blow on the eye; the contact of two different metals, one piece being placed under the upper lip, and another under the tongue, make us perceive a flash in the same manner as if light had really struck the eye: this can only take place in consequence of a change in the optic nerve similar to that which light itself produces.

Other phænomena afford some farther notions

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tions respecting the nature of this change. It seems, for example, that the sensitive faculty is consumed or exhausted, not only in a body fatigued by too lively or too long continued sensations, but also in each particular organ. Feeble sensations are scarcely perceptible when they succeed those that are much stronger; a sensation becomes weaker by duration, though the external bodies which cause it remain the same: for example, if at twilight we look stedfastly towards a point of the sky, in which some obscure body appears upon the azure ground, and afterwards turn the eye to another part of the sky, we shall still continue to see the figure of the obscure body; but that figure will then appear more luminous than the rest of the sky. The cause of this is, that the part of the retina, on which the shade fell, receives a stronger impression from the light than the part of the same membrane which was exposed to its rays before, while the former part experienced a kind of repose. For the contrary reason, after the eye has been fixed on a very luminous body, it sees for a time an obscure spot of the same shape as that body.

The other senses afford similar examples, but they are not so evident; because in this we have the advantage of comparing two parts of the same organ, which have been both acted upon, and one of which has experienced the action for a longer time than the other.

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This experiment shews that the nerves are not merely passive agents with respect to our sensations; and that they are not simply the conductors of a matter furnished by external bodies, nor even the reservoirs of a matter in which these bodies may excite vibrations, but that the substance which produces sensation is liable to be consumed, or to lose its activity, by exertion.

There are phænomena which shew that the general susceptibility of the nerves, for receiving sensations, may vary in consequence of causes external to the nerves themselves, and which can only operate by altering their substance. Certain medicines weaken or revive that susceptibility—inflammation frequently increases it to an excessive degree. Does this take place in consequence of an increased secretion of the nervous matter? the most remarkable change that occurs in the susceptibility of nerves, is sleep. It is not unnatural to suppose that this change may be occasioned by the temporary loss of the substance which is essentially sensitive. But how does it happen that sleep depends, in a certain degree, on the will? Why do we awake suddenly, or from causes which do not appear calculated to restore that substance? Why does cold produce sleep? From these observations may it not rather be supposed that this state is the effect of a change in the chemical nature of the nervous substance?

But whether the substance contained in the
nerves

nerves is exhausted by sensations; or whether it merely undergoes an alteration in its chemical composition, and becomes, as it were, naturalized, it must remain in the nerve throughout the whole of its course, and leave it only at one of its extremities. It does not, however, resemble the blood in the vessels, either as to the manner in which it is retained, or in which it moves in the nerve. There is no evidence of the nerves being tubular. No phenomenon indicates that any matter escapes from them when they are divided. Besides, what vessels could have parietes sufficiently compact to retain so subtle a fluid as that of the nerves must be. It is far more probable that it is retained in the nerves, in the same manner as the electric matter is in electric bodies, by communication and insulation; and that the nervous system is its only conductor, while all the other parts of the animal body are, with respect to it, cohibent substances.

In whatever manner the received action is transmitted, it is necessary, at least in all the higher orders of animals, that it should be propagated to the brain. But what part of the brain is particularly destined to receive its impression? Considerable portions of that viscus have been lost by wounds, without producing any diminution in the sensitive faculty. When wounds have penetrated farther, they have caused pains and convulsions which have too much

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altered the result of the experiment. These means, therefore, are not capable of resolving the question. It has been endeavoured to form some conjectures founded on the structure of the parts. It has been generally imagined that the common sensorium must be found in some central part, with which all the nerves might be supposed to communicate: some have chosen for this part the pineal gland, others the corpus callosum; but the latter exists only in the mammalia and the pineal gland, only in red-blooded animals; the latter even is not very apparent in all fishes. The cerebellum is the only part of the brain which constantly exists in all animals that have a visible nervous system; and on this account it might have some claim to the possession of this common sensorium: but it has been suggested by M. Sæmmering, that a solid part is not sufficiently moveable, nor alterable, with sufficient promptitude, to admit the impressions of the nerves with that rapidity which really takes place. Having besides observed, that all the nerves appear to arise mediately, or immediately, from the parietes of the ventricles, and that these ventricles always contain a certain quantity of water; he has supposed that it is precisely this fluid which answers all the conditions of the problem, and that it ought to be regarded as the common centre of sensation.

To trace the nerve's motion to its centre, and

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to establish, with certainty, what we have hitherto advanced only as conjectures, more or less probable, is a task which the anatomist has yet to perform.

How does it happen that an idea or image, of which we are conscious, is formed within us, at the moment this change takes place in the nervous system? How are those ideas accumulated in our memory? By what means is our imagination able to re-produce them, and our judgment to combine them, draw conclusions, and form abstractions from them? These, and other effects of habit and attention, the metaphysician may establish historically, but the physiologist cannot explain.

Physiology, however, shews us that there is a certain order of corporeal motions which correspond exactly to those sensations and combinations of ideas: study, too long continued, produces a sensation of fatigue in the brain. Certain states of disease change the natural order of ideas; suppress, or constantly present them of a certain kind; perplex and disorder the imagination: age renders our ideas less vigorous; wine and opium produces considerable changes in them. Other aliments, or other medicines, produce less important alterations; but each operates according to its species, and according to the disposition of the subject. Besides, the imagination and the will produce physical effects on the body, which seem to be a repercussion of

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the influence which the physical changes of the body has on them.

These effects of the will and the imagination constitute two other classes of animal actions, originating in the nervous system. That which includes voluntary motion was considered, in the first volume of this work, in treating of the muscular fibre: it was there shewn that the nerves are the organs by which the will excites the contraction of muscles, and that it is probable this contraction takes place in consequence of a chemical change which the nerve produces in the fibre. But is the matter that causes this change the same as that which excites sensation, and is it transmitted by the same portion of nerve? How does it happen that, in certain diseases, we preserve the free use of our members, while they are totally deprived of sensibility? Is this the consequence of an alteration which affects only the external organ of feeling, and not the nerve? In the night-mare, why is our strong desire to escape from the imaginary objects that oppress us ineffectual, and why is the will incapable of producing the smallest motion in the body? When a nerve, which has been divided, is afterwards united, why is motion only re-established, and not sensation?

Some have supposed that the envelopes of the nerves form the conductor of their moving power, and their medullary part that of their sensibility. To the reasons which they have advanced

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vanced in support of this opinion, we may add, that the envelopes communicate with the ventricles by the plexus choroides, which are continuations of the pia-mater. It must be confessed, however, that this idea can as yet be regarded only as an hypothesis.

There are effects which belong to the imagination, as voluntary motion belongs to the will; they are confined almost entirely to a sudden augmentation of certain secretions, or the accumulation of blood in certain parts. Before we attempt to explain these effects, it is necessary to enquire how far the nervous system participates in the purely vegetative functions of our body.

The part it performs in that respect is very decided. We know that the influence of the nerves on the vital organs, and of the latter on the nerves, is reciprocal. Grief, or an excessive application of the mind, alters digestion, and diminishes the secretion of the gastric and seminal fluids. On the other hand, an over-loaded stomach blunts sensibility, and induces sleep. If this kind of excess be too frequently repeated, stupor seizes the mental faculties. Too great a waste of the spermatic fluid destroys memory, extinguishes imagination, and produces extreme irritability and fearfulness. Remedies, calculated to restore the powers of the mind, give also new energy and vigour to the vital organs. The diseases which most enfeeble the powers of
1 3 perception

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perception and understanding, also reduce the body to an inert state, which is speedily followed by dissolution. Mental excitation is usually accompanied by heat, irritation, and an increased energy in all the vital motions.

Upon an attentive examination of this subject, it will appear that the part the nerves perform, in all these functions, may be reduced to their influence on the irritability of the arteries: by preserving this irritability the nerves promote circulation to the extremities of the vessels, and keep up all the secretions. When the excitement of the nerves heightens the irritability, the secretions are augmented.

All the physical changes that take place in the body, in consequence of the images that occupy the mind, belong to the same class of action. In general the mind possesses no influence over the organs of circulation, and the will cannot stop their motion: but when lively images heighten the excitement of the whole, or a part of the nervous system, the mental influence extends to those muscular fibres which produce circulation: thus the hope of a much desired event causes the heart to palpitate. Voluptuous ideas make the blood flow into the cells of the corpora cavernosa of the penis, and produce erection; anger or shame impells it to the skin of the face, whence it is driven back again by the re-action of the vessels: this is the reason why these passions produce alternate blushing

blushing and paleness. Sudden terror instantly augments the secretion of the fluids of the intestines, and causes a diarrhœa. The sight of a good meal occasions a great secretion of saliva in a hungry man; even mentioning victuals is sufficient, according to the common phrase, to *make his mouth water*; in the same manner speaking of disgusting substances, serves to sicken the stomach of men of delicate feelings. Excessive sorrow or joy increases the secretion of the tears so considerably, that they cannot flow through the lachrymal points, but fall upon the cheek.

In other cases the action of the imagination does not extend beyond the nervous system; it is confined to the production of sensations in certain parts of the body, independently of any external impression. Fear and uncertain hope always excite a singular sensation in the præcordial region. This sensation, which doubtless takes place in the nervous plexus of that region, is usually the precursor of that alvine excretion which is excited by the nerves proceeding from these plexus; in the same manner as, by a contrary movement, the accumulation of blood in the corpora cavernosa of the penis precedes that vivid sensation which has reached its height at the moment of the expulsion of the semen. Efforts made to recollect certain painful feelings which we have experienced, sometimes bring back those sensations themselves.

The susceptibility of the nervous system to be thus governed by the imagination, may be more varied than the capacity it possesses for receiving external impressions. The age, sex, and health of the individual; the manner in which a person has been educated, either with respect to his body or moral principles; the empire which reason holds over his imagination, and the temporary state of his mind, all produce in this respect astonishing differences; which may be compared to those that disease, sleep, medicines, &c. may occasion in the susceptibility of the nerves for external impressions.

There appear besides, in the nervous system, certain phænomena which depend on the union of different nerves, whether that communication be produced by cords passing from one to the other, or through the medium of the brain. These phænomena are called *sympathies*: they consist of involuntary motions, or rather of sensations, experienced in places different from those that are affected. These sensations do not seem to depend upon the influence of the will, or the imagination, and frequently exist while we are ignorant of the place really affected, or the motion that has occurred.

The sneezing which succeeds to irritations of the nostrils, affords an example of the sympathy produced by the union of nerves: the nerves of the nostrils, which come from the ophthalmic branch of the fifth pair, are connect-
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ed by the sympatheticus major, with the nerves of the diaphragm, and by this means the excitement is communicated. The sneezing which takes place upon looking at a bright light, is to be ascribed to the union of the ciliary nerves with the fifth pair: the irritation is communicated to the nose, and thence to the diaphragm.

Another example of the same kind consists in the great changes which the eyes present in different internal diseases of the body. These changes, so important to the physician, are almost all produced by the union of the sympatheticus major with the fifth pair, and by that pair with the ciliary nerves.

Sympathetic actions occur still more frequently, when different parts of the body receive branches of the same nerve, which may communicate irritation.

Thus tears are excited by a strong smell. This is occasioned by the ophthalmic nerve sending at the same time branches to the nostrils and the lachrymal gland.

The vomiting produced by pushing a finger into the throat, is owing to the distribution of the eighth pair of nerves, which go both to the pharynx and the stomach.

This eighth pair, or nervus vagus, and the great intercostal or trisplanchnicus, are the nerves which produce the greatest number of this kind of phænomena, because they are distributed

buzed to a great number of parts, and form unions with a great many other nerves; they have therefore been named *sympatheticus major*, and *sympatheticus medius*.

To conclude this brief account of the action of the nervous system, we should also notice the influence which the nervous system of two different individuals may exercise upon each other. The abuse which has been made of this influence by impostors, and the exaggeration with which it has been described, have brought the subject into such contempt, that philosophers can scarcely think themselves permitted to mention it.

It must be confessed, that it is extremely difficult, in the experiments which have this action for their object, to distinguish the effect of the imagination of the person subjected to the experiment, from the physical effect produced by the operation; and the problem is frequently very complicated. The effects, however, obtained on persons who were insensible before the process commenced, those that appear in others after the operation itself has rendered them insensible, and those exhibited by different animals, place it beyond all doubt, that the proximity of two animated bodies, in certain situations, and with certain motions, produces a real effect, independent of any participation of the imagination of one of them. It also appears sufficiently evident, that these effects

fects take place in consequence of a certain communication being established between their nervous systems.

Finally, it were to be wished that we were able to compare the action of the nervous system, in the different orders of animals, in the same manner as we shall compare its structure and distribution : but this examination presents insurmountable difficulties ; because we have no means of discovering the manner in which animals are affected, except by very equivocal marks.

In all animals that have nerves, voluntary motions, and direct sensations, take place by the same means as in man. The differences in their motions depend partly on the intrinsic mobility of their fibres, and partly on the disposition of their muscles, and the parts to which they are attached. These differences have been explained in the first part of this work.

The differences in their sensations depend on the number of their senses, and the perfection of the organs belonging to each sense. The animals that approach nearest to man have their senses equal in number to his. In certain species some of these senses are even more perfect in the structure of their organs, and susceptible of more lively and delicate impressions than ours : on the contrary, in proportion as animals are removed from us, the number of their senses and the perfection of certain organs are diminished ;

nished; but perhaps some animals at the same time possess senses of which we can form no idea. We shall particularly consider these subjects in this second part of our work.

We know not whether there are differences in the intrinsic sensibility of the nervous system of different animals; that is to say, whether an equal impression, applied to an organ equally perfect, would affect every animal with the same force. This it is evident we shall never be able to learn.

The animals next in order to man have, like him, spontaneous sensations. Images are excited in them at times when they receive no immediate impression from external objects. Dogs and parrots dream; but we are not certain whether the very inferior species of animals experience similar sensations.

The passions produce effects in animals which resemble those they produce in us. Love is manifested in the same manner in all classes: terror occasions a discharge of excrements in quadrupeds and birds: fear makes them tremble, and even renders insects immoveable; but the other animals afford fewer examples of these kind of phænomena than man, because they are not masters of their imagination, cannot direct it towards certain objects and create for themselves fictitious passions. We are even ignorant whether their imaginations can, like ours, be wrought up to such a pitch as to make them
experience

experience emotions of anger, desire, or fear from simple ideas or simple recollections; and whether the real presence of the objects which cause these passions, is not always necessary to excite them in the inferior animals: we know, however, that those which approach nearest to us, the mammalia and the birds, have their sorrows. The affliction they feel on the absence or loss of a companion, friend or benefactor, is manifested by evident signs, in the same manner as they testify their attachment without any temporary inducement.

The same animals exhibit frequent proofs of a very perfect memory; some even appear to possess a certain degree of judgment.

But does any thing similar exist in the inferior classes, and particularly in the lowest? of this we shall probably remain always ignorant.

With so much resemblance in the structure of the nervous system, in its mode of action, and in the number and structure of the principal external organs, why is there so vast a difference, as to the total result, between man and the most perfect animal?

Is this owing to a more accurate proportion in the relative perfection of the external organs, so that one does not too much surpass another? or has the internal organs, in which are performed all the intermediate operations between the sensation received and the movement executed, that is to say, the organ of perception,
memory

memory and judgment, greater differences than we have yet observed? or finally, is the substance by which these processes are effected of a different nature? These, however, are not anatomical questions.

The sympathies or effects resulting from the connections of nerves with each other, and the influence of the nerves on the vegetable or vegetative functions, are subject to the same laws in man and the other animals.

ARTICLE III.

General Comparison of the different Nervous Systems.

ON comparing together all the nervous systems, we find only one common part, which is a single tubercle, situated at the anterior extremity of the system, and always producing two lateral and transverse fasciculi or crura, which unite it to the rest of the system.

This part appears always to correspond to that named *cerebellum* in man. The *cerebellum* of animals that have red blood and vertebræ, is always preceded by several pairs of tubercles, forming usually a larger mass than the *cerebellum* itself, and united to the rest of the system
by

by two longitudinal fasciculi or crura, which are interwoven in crossing with those of the cerebellum. This union takes place in such a manner that both are confounded in the common mass which forms the root of the medulla oblongata, and medulla spinalis, and leave no space between them. These tubercles make what we call the cerebrum. They present considerable differences in the various classes of animals, which we shall explain in subsequent articles.

In the white-blooded animals, or those that have no vertebræ, there are also tubercles situated before the part corresponding to the cerebellum; but these tubercles are a great deal smaller, much removed from each other, and connected with the cerebellum only by separate nervous filaments. The crura of the cerebellum leave a large interval between them, which receives the œsophagus as in a collar.

The long production of the brain, called the medulla oblongata, and medulla spinalis, in vertebral animals, is situated on the back, above the intestinal canal, and is inclosed in the canal of the vertebræ. The two fasciculi which form it are intimately united, and no trace of their separation remains, except a longitudinal furrow before and behind. But in the animals that have no vertebræ, when this production exists, it is formed below the œsophagus by the union of the two crura of the cerebellum. These two fasci-

fasciculi commonly remain distinct throughout the greater part of their length, and are only united at different spaces by knots from which the nerves proceed. This production, however, frequently does not exist. In some animals with white blood, which have no elongation of the medullary substance, as in the *Molusca*, the nervous trunks, which are derived from the crura of the cerebellum, enlarge and form ganglia, or two or three nerves unite with each other to produce a common ganglion; and in general it is only from their ganglia that the nerves, which are distributed throughout the body, take their origin.

In those white-blooded animals that have a knotted and double medullary production, that is to say, the insects, the crustacea, and certain worms, the nerves all arise from the knots or ganglia of the medulla, or from some of the anterior ganglia of the cerebellum.

In the red-blooded animals the nerves of the spine arise from the medulla spinalis in two bundles of medullary filaments, which unite after the posterior bundle has formed a ganglion. They afterwards separate into two trunks, the anterior of which communicates with the great sympathetic nerve by one or two filaments, and a ganglion is always formed at the place where they unite.

The nerves of the brain do not arise precisely in the same manner, the different tubercles
which

which form it, however, seem to serve as ganglia. This at least is evident in the corpora striata, with respect to the olfactory nerves; and in the thalami nervorum opticorum, with respect to the optic nerves. The nerve of the fifth pair has a particular tubercle, which is very conspicuous in fishes. The corpora olivaria may be considered as the ganglia of the eighth pair. There are no tubercles apparently belonging to the third and fourth, though the *testes* may perhaps be assigned to the latter.

The sympathicus major, which is constantly found in all red-blooded animals, exists in none of those with white blood; unless we should regard, as that nerve, the two nervous cords which unite all the ganglia, and which we have called medulla spinalis in the crustacea, insects, and worms.

Were this opinion adopted, a medulla spinalis would no longer be attributed to these animals, and the absence of that production would then be the common character of all the white-blooded classes.

ARTICLE IV.

*Description of the Human Brain.*A. *The Brain of Man viewed on its superior Surface.*

WHEN we remove the upper part of the cranium and the dura-mater, there appears an oval substance, the length of which is to its breadth nearly as 4:3. This oval contracts a little anteriorly. Its convexity is pretty uniform, and nearly half as high as broad.

A deep fissure, which receives the falx, divides this oval longitudinally into two nearly equal parts, called hemispheres.

In this view we do not see the cerebellum, because that part is entirely covered by the brain.

The furrows of this surface are very numerous and deep. The depth of some is equal to 0.021 metre. They convolute in various directions. The parts of these intervals, which are visible externally, are about 0.01 metre broad, more or less; these convolutions have the appearance of a number of small intestines.

Reckoning those which touch the fissure that divides the two hemispheres, we find eighteen or twenty. Reckoning transversely, we find ten

or

or twelve: but these numbers depend upon that part in which they are counted.

The surface by which each hemisphere is opposed to the other is plane; we find furrows in it as well as in the convex surface. Its height is 0.04. The falx, which is not so high, does not separate these surfaces entirely; and the hemispheres unite below the falx by vessels and cellular substance.

On separating the hemispheres, we observe, at the bottom of the fissure, which divides them, a kind of bridge of medullary substance, which extends from the one to the other, and disappears under them. It does not cover the whole length of the fissure, but leaves anteriorly a space equal to one-third of its length; and posteriorly another space which is double the former: the bridge then is only half the length of the hemispheres. We observe that it folds under itself at both extremities.

B. *The Brain of Man viewed laterally.*

In this view the superior margin of the brain presents a curved line, which resembles one half of an ellipsis; but its inferior margin is very irregular. It first exhibits a concave line, which extends downward from the posterior extremity to the middle of the total length, which is also the lowest point. The cerebellum, which

is entirely covered by the cerebrum, is situated under this concave line.

The area of the cerebellum, viewed thus in profile, is scarcely equal to one-eighth of that of the cerebrum; the part of the brain situated above the cerebellum, is called the posterior lobe of the cerebrum; the part projecting downward, which is terminated by the before-mentioned concave line, is called the middle lobe; this line bends forward, and after being continued in a convex form, terminates in a deep sulcus, which is directed backward on the lateral surface of the brain, and completes the division of the middle lobe from the anterior. The anterior lobe, situated before the sulcus, occupies nearly one-fourth of the whole length of the cerebrum; but inferiorly, and towards the middle line, it is prolonged backward to the internal side of the middle lobe, at the depression which contains the pituitary gland.

The furrows on this lateral surface of the brain are as numerous, and as irregular, as those on its superior part.

C. *The Brain of Man viewed inferiorly.*

The lower surface of the human brain exhibits four eminences, which correspond to the fossæ of the *basis cranii*: one of these eminences is situated posteriorly, and comprehends the inferior

ferior surface of the cerebellum, the medulla oblongata, and the pons Varolii: the two lateral and intermediate eminences form the middle lobes of the cerebrum: the two that are situated farthest forward, are called the anterior lobes.

Between these four eminences there is a deep depression, which contains the infundibulum, the tubercula mammillaria, and the origin of the optic nerves, and above which, in this inverted position, we observe the pituitary gland.

The posterior eminence is an irregular oval, the transverse diameter of which is, to the longitudinal, nearly as 4:3: this oval is deeply notched posteriorly, in consequence of the division of the cerebellum; anteriorly, on the contrary, the pons Varolii forms a rounded projection, corresponding to the depression in the middle of the base of the cranium.

The exterior outline of the *two lobes of the cerebellum*, is round; their surface is moderately convex, nearly equal, and has two remarkable eminences, viz. one a little without, and behind the place where the pons Varolii loses itself in the substance of the brain; and another, which is larger and oval at the anterior part of the line by which the two lobes of the cerebellum join. Their whole surface is marked with slight, and nearly parallel furrows, about a line distant from each other; their direction is almost parallel to the edge of the lobes, except towards the anterior, which they cut obliquely.

The *processus annularis*, or *pons Varolii*, represents a kind of crescent; its anterior edge is convex, and almost semi-circular; its posterior edge is concave.

Its surface exhibits a medullary substance, the fibres of which are parallel to each other, and to both edges; they approximate outwardly, to form the two horns of this kind of crescent, and are lost in the cerebellum, under, or rather upon the little round eminence. This annular protuberance corresponds to the basilar fossa of the os occipitis: its greatest breadth is double its length.

The *medulla oblongata* appears immediately behind the pons Varolii, by which it seems to be bound, as with a collar; its base is broadest, and it contracts, by degrees, so as to represent a kind of bulb: we observe a longitudinal furrow on its middle, and another on each of its sides; within each lateral furrow there is a slight oval eminence, which both together are called *corpora olivaria*: between each corpus olivarium, and the middle furrow, there are some longitudinal fibres, called *corpora pyramidalia*; there is a small triangular depression between the bases of these pyramidal eminences, and the posterior edge of the pons Varolii. Another depression is also observed between the corpora olivaria, which separates them from the same edge. The fibres of the portion of the medulla oblongata which is situated without each corpus olivarium,

rium, are directed obliquely outward and forward.

The two lateral eminences, or *middle lobes of the cerebrum*, are nearly of a triangular shape; they are marked by irregular furrows, like all the other parts of the surface of the cerebrum; they are separated from the anterior lobes by a groove, called the *fissure of Sylvius*, which receives the posterior edge of the small wings of the sphenoid bone.

All the parts before these two eminences belong to *the anterior lobes* of the brain; these are less convex, and less elevated; they likewise exhibit irregular furrows, and in this inverted position the olfactory nerves are situated upon them, parallel to the middle line which separates them.

To distinguish the parts situated between these four eminences, the cerebellum, and the pons Varolii, must be pressed backward, and the middle lobes towards the sides: we then perceive the *crura* of the cerebrum, which are two cylindrical medullary bodies, and appear to the eye to be the continuation of the medulla oblongata, after its passage under the pons Varolii: they touch each other by their internal edges; after proceeding forward, and a little outward, they sink each on its respective side, under the mass of the cerebrum, between its anterior and middle lobes: at this place, each of the *crura* is crossed by one of the optic nerves, which

arise from the same depression, and are directed forward, and obliquely inward, to unite in the middle line. Between the crura of the cerebrum, and the optic nerves, there is a space at the posterior part, of which we observe two round white eminences, called *tubercula mammillaria*. The remainder of this space is occupied by a cone, formed of an ash-coloured substance, and called *infundibulum*; this cone is prolonged into a slender stalk, that adheres to the union of the optic nerves, and terminates in the pituitary gland, which, in this inverted position, is uppermost, and covers it.

D. *Developement of the Brain.*

To obtain a right knowledge of the internal parts of the brain, it is necessary to divide the crura cerebri immediately before the cerebellum, and the pons Varolii: we then find that the cerebrum is connected to the rest of the brain, by only a crescent, about 0,03 broad, which makes precisely the section of the crura, and which occupies nearly the middle of the inferior surface of the cerebrum, thus separated.

The continuation of its superior margin is interrupted by the section of the *aqueduct of Sylvius*, of which we shall speak hereafter. On separating a little the crura of the cerebrum, we observe a kind of small medullary bridge over
this

this aquæduct: on the superior surface of this bridge there are four eminences, which have been named *tubercula quadrigemina*.

The two superior and anterior eminences, called *nates*, are of an oval form, and rather larger than the others; the inferior and posterior, called *testes*, are round, but they are prolonged obliquely to the external sides of the *nates*.

Where this prolongation meets the root of the optic nerve, which, as we have already observed, crosses the crus, as it ascends obliquely backward, we observe another eminence, which may be regarded as forming a third pair of tubercles*. Between the *testes* posteriorly, there is a small triangular frænum, which is of a greyish colour, and somewhat hard.

A little before the optic nerve reaches the lateral eminence of the *testis*, it is enlarged and divided by a furrow into two parts; the most external of which forms a small oval tubercle, and afterwards seems to expand over the posterior part of the large eminence, called the *thalamus nervi optici*.

The superior surface of the two optic thalami, which is situated under the cerebrum, represents a triangular space, having a notch posteriorly, which contains the *tubercula quadrigemina*; the sides of this space are round, and the middle is depressed

* Vicq-d'azir, pl. XVI, No. 54.

depressed longitudinally : on separating the thalami, we observe that they are intercepted by a cavity, called the *third ventricle* : this cavity is also divided : there is extended, from one of its surfaces to the other, a production of a pulpy and almost fluid substance, which is named the *soft commissure* of the *optic thalami*.

This ventricle communicates by the aquæductus Sylvii, which passes under the tubercula quadrigemina, with another which is under the cerebellum, and is called the *fourth ventricle*.

The anterior part of the third ventricle penetrates between the tubercula mammillaria, and the union of the optic nerves, to form a kind of funnel of a pulpy substance, which we have already noticed, under the name of *infundibulum*.

Each superior edge of the third ventricle is marked by a white line, which is prolonged backward, to form the peduncle of the *pineal gland*, which is a small oval ash-coloured body, suspended above the tubercula quadrigemina. The same white line extends forward towards the lower part, and then bends suddenly back, to join a thick medullary cord, which forms one part of the anterior pillar of the fornix.

A little more forward we observe a transverse medullary cord, which passes from one side of the cerebrum to the other, and which is called its *anterior commissure*.

There is another commissure nearly similar, over the entrance of the aquæductus Sylvii, and
under

under the peduncle of the pineal gland; it is named the *posterior commissure*. The entrance of the aquæduct is denominated the *anus*.

Between the anterior commissure, and the union of the optic nerves, there is a space which is inclosed only by the pia-mater, and a very thin stratum of that pulpy substance which lines the inside of the third ventricle: this is named the *vulva*.

On the outside, and before the optic thalami, we find two eminences, which are also concealed under the cerebrum; these are called *corpora striata*, on account of their internal texture, which we shall describe in another place.

The corpora striata are broad anteriorly, where they approach the middle line of the brain; they are contracted posteriorly, and removed from each other to make room for the optic thalami; they end in a sort of tail, which follows exactly the outline of the thalamus, and the root of the optic nerve, and are terminated inferiorly by a small obtuse enlargement; thus each corpus striatum resembles a horse-shoe, with one of the branches considerably longer than the other. In the natural position of the brain, this horse-shoe is situated on its narrowest side, so that the large branch is uppermost, and a little more forward and inward than the other.

In the furrow, which separates the corpus striatum from the optic thalamus of the same side,

side, there is a band of medullary substance, which takes the same course as the furrow, and is named *linea semi-lunaris*.

All the part of the cerebrum that is visible externally, is a kind of appendix of the corpora striata, but an appendix which greatly surpasses them in size in man. The mass of each hemisphere is joined to the whole external margin of the corpora striata. After proceeding downward and outward, it turns upward and inward, to rest on that of the opposite side and join the corpus callosum. The portion of this mass which joins the inflected cauda of the corpus striatum, forms what is called the *middle lobe*.

The posterior part of the hemispheres, and the corpus callosum itself, bend downward, and the inflected part penetrates under the former, covering the tubercula quadrigemina and the optic thalami. In this manner, but always contracting, it arrives above the anterior commissure of the cerebrum, where it is terminated by two medullary cords, which penetrate into the substance of each thalamus. This fold has obtained the name of the *fornix with three pillars*: posteriorly it is united immediately to the inferior surface of the corpus callosum; anteriorly this union is formed by two medullary laminae, which form a very thin partition, called *septum lucidum*. The margins of the fornix extend backward, separating at the same time from each other so as to form a triangle, and descend
into

into the interior of the middle lobe, preserving nearly the same curvature as the caudæ of the corpora striata. Behind each of these margins there is a swelling of the breadth of a finger, which still keeps the same curvature, and is called *cornu ammonis*, or *pes hippocampi*: under the same edge there is a greyish serpentine band which appears fringed, and is named *corpus fimbriatum*.

The inferior surface of the fornix is marked by one or two longitudinal striæ on its middle and anterior part. Posteriorly we observe some transverse fibres, which are the continuation of those of the corpus callosum. The different folds of which the hemispheres are composed, do not join each other by their internal surfaces; they are intercepted by a large cavity in each hemisphere: these two cavities are the *anterior ventricles of the cerebrum*. With respect to their form, they may be compared to an Italic capital \mathcal{L} situated thus \mathcal{L} . The vault of their superior branch is formed by the corpus callosum, and its floor by the corpus striatum: the descending branch contains the cauda of the corpus striatum anteriorly, and the cornu ammonis posteriorly. The angle formed by the union of these two branches penetrates backwards into the portion of the hemisphere which is situated above the cerebellum, where it forms a blind cavity which bends inwardly; it has received the name of the *digital cavity*: on its internal surface

surface there is a small eminence, called the *ergot* or *spur*.

The two ventricles are separated anteriorly by the *septum lucidum* only, and they would open into each other under the fornix, were it not for a production of the pia-mater, which we shall describe hereafter under the name of plexus choroides, and which leaves them no communication except a small hole near the anterior pillar. By the same passage they communicate with the third ventricle, and by that with the fourth: thus those four cavities may be said to form only one.

There is a fifth cavity between the two layers of the *septum lucidum*, but it has no external communication. This is the *fifth ventricle*.

The cerebellum is connected to the rest of the brain by two medullary trunks, one on the right and the other on the left, which seem to take root in its internal substance, in order to produce a crucial intermixture of their fibres with those of the medulla oblongata. The fibres of the inferior plane of each of these trunks, are continued to form the pons Varolii, and to unite together on the middle line: those of the superior plane form a more slender fasciculus, which is directed towards the testes, and which is joined to the fasciculus of the opposite side, by a very thin medullary lamina, called *valvula cerebri*. The posterior edge of this valve is united to the mass of the cerebellum.

The cerebellum is not in contact with the superior surface of the medulla oblongata, but is placed over it like a bridge. The interstice between them is called the *fourth ventricle*.

This cavity communicates with the third by the aquæductus Sylvii. In the bottom of this ventricle we observe an angular impression, called *calamus scriptorius*.

The cerebellum itself is divided into three parts; the two lateral, which are most considerable, are called its lobes. The middle, which is the smallest, and concealed in the fissure that separates the two other parts, is named the *vermiform process*.

E. *Sections of the Brain.*

There are different methods of dissecting the brain, in order to shew its structure. Some sections are vertical, others horizontal and oblique.

1. *Vertical Sections.*

The most important of the vertical sections is that which divides the brain into two equal parts, leaving the two hemispheres, as well as the corpora striata and optic thalami untouched; and bisecting the corpus callosum, the fornix, the three commissures, the glandula pinealis,

nealis, the tubercula quadrigemina, the pons Varolii, and the medulla oblongata.

This section shows, 1st, that the corpus callosum, has a curvature nearly parallel to that of the vault of the cranium, and that it folds under itself both anteriorly and posteriorly. 2dly, That the fornix is a continuation of its posterior fold. 3dly, That the septum lucidum is a triangular space, included between the corpus callosum and the anterior fold of the fornix. 4thly, That the anterior commissure, the union of the optic nerves, and the mammillary tubercle, form a triangle which is almost equilateral. This section also affords a distinct view of the great space in the middle of the brain, which commences anteriorly at the infundibulum, then forms the third ventricle, the aquæductus Sylvii, and the fourth ventricle. The section of the latter is triangular; that of the aquæduct is long and narrow; that of the third ventricle is nearly semi-circular, and its part which descends towards the infundibulum, is almost square. The division of the medulla oblongata and pons Varolii, exhibits crucial fibres more or less remarkable. We sometimes observe a fasciculus arising near the fourth ventricle, which, after bending, gives origin to the third pair of nerves.

A section of the cerebellum displays some medullary lineaments, representing a tree with five principal branches, which are sub-divided
twice

twice in succession into smaller ramifications. This is called *arbor vitæ*. All the parallel sections made more towards the sides exhibit the same figure.

On penetrating the interior of this vertical section, towards the external side, we discover several particulars worthy of notice: 1. That the peduncle of the anterior pillar of the fornix passes into the substance of the optic thalamus, to terminate in the tuberculum mammillare. 2d, That another medullary fasciculus departs from this tubercle, and also traverses the substance of the optic thalamus to near its superior surface. 3d, That the fibres of the crura cerebri are continued across the optic thalamus to the corpus striatum, and across the pons Varolii to the medulla oblongata. 4th, That a small greyish line winds in a serpentine manner round the corpus olivarium internally. As this line is seen in whatever direction that eminence is cut, it is obvious that it must contain a body of a very irregular surface, and covered with a thin layer of a greyish substance, the sections of which exhibit these linear appearances.

2. *Horizontal Sections.*

The horizontal sections may commence with the superior or inferior surface.

When we cut the two hemispheres superiorly at the level of the corpus callosum, we discover

the greatest medullary space that can be demonstrated in the brain. The grey substance appears on the edges only, all the rest is white, and is named the *centrum ovale of Vieussens*.

If we dissect farther downward, the two anterior ventricles soon appear. From this view we observe that their anterior cornua are approximated, while the posterior are removed from each other.

The corpus callosum being completely removed, the fornix is rendered visible, and we can discern very distinctly its triangular form. After this we expose the fifth ventricle, by separating the two lamina that form the septum lucidum. Then cutting the anterior pillar of the fornix, and throwing the fornix itself backward, we lay entirely open the superior surface of the optic thalami, the aperture of the third ventricle, the three commissures, and the tubercula quadrigemina. The eye may even penetrate into the infundibulum.

On making deeper sections, we observe that the interior of the corpora striata is filled with white striæ, which seem to arise from the optic thalami, and through them from the crura of the cerebrum. From the white striæ being separated by others of a cineritious colour, these eminences have obtained the name of *corpora striata*.

Penetrating still farther, we observe that the anterior commissure of the cerebrum extends on
each

each side into the substance of the optic thalami, in a white line somewhat resembling a bow. The posterior commissure is lost almost as soon as it enters the substance of the optic thalami.

The tubercula quadrigemina, divided horizontally, present an almost uniform greyish substance.

The horizontal sections of the cerebellum exhibit some white lines passing from right to left, and which are precisely those that form the arbor vitæ in the vertical sections.

The horizontal sections of the medulla oblongata, and pons Varolii display the same direction in the fibres as we have already described. Those of the crura of the cerebrum have a dark brown spot internally.

On making horizontal sections in the inferior surface, we discover several remarkable circumstances; 1. The posterior fold of the corpus callosum, which forms inferiorly a large roll behind what is properly called the fornix. 2. The two corpora fimbriata, each of which proceeds from one of the extremities of this roll, and extends to the posterior pillars of the fornix, the curvature of which they exactly follow. 3. The section of the crura of the cerebrum, in which we observe the black spot, which in this view appears semicircular. 4. In this manner we shew the inferior surface of the fornix and *lyra* in the natural situation. Lastly, on removing the fornix, we discover the inferior surface of the corpus cal-

losum, that is to say, the roof of the lateral or anterior ventricles, to the middle part of which the septum lucidum adheres by the two laminæ of which it is composed.

F. *Of the Origin of the Nerves.*

1. *The Olfactory Nerve.*

The olfactory nerve lies under the anterior lobes of the cerebrum, in a furrow near and parallel to the middle line.

The anterior extremity, which is situated upon the cribriform lamella of the os ethmoides, consists of a grey substance. The remainder of the length of the nerve is white, and of a triangular prismatic shape. Its base is enlarged and divided into three roots, distinguished by an equal number of white filaments, which terminate in the grey substance of the brain. That which is internal is directed outward, until it reaches the fissura Sylvii, where it is lost. The external ascends upon the internal surface of the hemisphere as far as the corpus callosum. The middle one is much shorter than the other two, and is even sometimes wanting.

2. *The Optic Nerve.*

The optic nerve evidently arises by the fibres, which we observe at the superior part of the optic
7 thalami.

thalami. It descends outwardly, and surrounds, in the form of a ribbon, the crura of the cerebrum, from which it is separated on its internal edge, but united to them by its external. It approaches to the middle line before the infundibulum, where it is intimately united with its correspondent nerve, in such a manner that neither the eye nor the knife can discover whether they cross each other, or are only simply joined. After this union, they separate again to go out of the cranium by the optic foramina. The portion which is anterior to their union is cylindrical.

3. *The Oculo-muscular Nerve.*

This nerve arises near the middle of the crus of the cerebrum, a little before the pons Varolii, but its origin may be traced into the body of the crus. It is a medullary filament, which, in ascending, bends backward under the floor of the fourth ventricle. It has been erroneously supposed that this filament proceeded to the tuberculum mammillare. This nerve is directed a little towards the side, in order that it may pass out of the cranium by the sphenno-orbital fissure, after it has traversed the dura mater.

4. *The Pathetic Nerve.*

Some filaments behind the testes, at the side of the little frænum, form the origin of this

nerve. Farther back, on the valvula cerebri, we observe several white fibres, some of which extend to the pons Varolii, and the others diverge, more or less, from that direction. These fibres sometimes appear to contribute to the formation of the nerve.

This nerve passes between the middle lobe of the cerebrum, and the adjacent part of the pons Varolii, and the crus. After a pretty long curve, it goes out of the cranium by the spheno-orbital fissure, behind the posterior clinoid processes.

5. *The Tri-facial Nerve.*

Each nerve of the fifth pair arises from that part of the crus cerebelli which contributes to form the pons Varolii, very near where the crus passes out of the cerebellum. M. Soemmering asserts that it may sometimes be traced into the substance of that crus, until it is lost under the floor of the fourth ventricle. It is very soft at its origin, but it soon becomes very hard, and is divided into a number of filaments, arranged in the form of a flat ribbon. This ribbon is composed of three fasciculi, on which account the nerve has received the name of *trigeminous* or *tri-facial*. These fasciculi themselves have each a particular name, viz. *nervus ophthalmicus*, *maxillaris superior*, and *maxillaris inferior*.

6. *The*

6. *The Abductor Nerve.*

The sixth pair of nerves commence on the posterior edge of the pons Varolii, by some filaments which come from the sulcus that separates that pons from the corpora pyramidalia. Some of the filaments appear to rise from the pons itself. They proceed directly under the pons Varolii, advancing towards the spine of the os petrosum, where they penetrate the cavernous sinus, whence they are transmitted to the orbit in the manner we shall hereafter explain.

7. *The Auditory Nerve, or Portio mollis of the Seventh Pair.*

The acoustic or auditory nerve appears to commence by several white fibres, which we observe on the inferior surface of the fourth ventricle, and which vary in number from two to five. These filaments approximate and descend to the sides of the base of the medulla oblongata, and there form the origin of this nerve, which separates from the mass a little more outwardly than the preceding. It is conveyed into the internal ear, where we shall follow its distribution in the article on the sense of hearing.

8. *The Facial Nerve, or Portio dura of the Seventh Pair.*

This nerve derives its origin from the sulcus, which separates the pons Varolii from the medulla oblongata, a little more outward than the corpora olivaria. It arises by a flat portion, and by another which appears somewhat more fibrous, but which is intimately united with the former. It enters the canal of the dura mater, which is common to it, and the portio mollis, with which it passes into the meatus auditorius internus.

9. *The Glossopharyngeus, par vagum, and nervus spinalis or accessorius, commonly called the Nerves of the Eighth Pair.*

The glossopharyngeus, and the vagum, arise from the sulcus, which forms the external boundary of the corpus olivarium. The glossopharyngeus is situated farthest forward, and is composed of three, four, or five filaments. The vagum is formed by a far more considerable number, which occupy all the rest of the sulcus.

The spinal nerve is formed by several filaments which arise on the sides of the medulla spinalis, as far down as the roots of the fourth, fifth, and sometimes the seventh cervical nerves. It approaches the vagum, and passes with it and the glossopharyngeus through the foramen lacerum posterius.

10. *The*

10. *The Great Hypoglossal Nerves.*

These form the twelfth pair, though they are generally demonstrated as the ninth. Each nerve arises from the medulla oblongata, a little below and between the corpora olivaria and pyramidalia, by a great number of small filaments which make a kind of circle. These filaments presently unite into two or three fasciculi, which pass through the os occipitis by the anterior condyloid foramen.

ARTICLE V.

Of the Brain of Mammalia.

THE brain of the other mammiferous animals contains precisely the same parts as that of man, and those parts are disposed in a similar order: it varies, however, in the proportion it bears to the rest of the body, to the cerebellum, and to the medulla oblongata; in its general form; in its circumvolutions; in its internal development; and lastly, in the differences which its base and the origin of the nerves exhibit.

1. *Proportion of the Mass of the Brain to the rest of the Body.*

It is very difficult, if not impossible, to establish this proportion in a comparative manner, because

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because the weight of the brain remains the same, while that of the body varies considerably according as the animal in whom the comparison is made, is fat or lean. Thus the proportion of the weight of the brain to that of the rest of the body, has been stated by one author to be in the *cat* as 1 to 56, and by another as 1 to 82; in the *dog* as 1 to 305, and as 1 to 47, &c.

The following is, however, a table of these proportions, collected from different authors, and from my own observations. It will appear that, all things considered, the smaller animals have the brain proportionally the largest; that man is surpassed in this respect only by a small number of animals, all of which are lean and meagre, as mice, small birds, &c.; that among the mammalia, the Rodentia have in general the largest brain, and the Pachydermata the smallest; and that cold blooded animals have it infinitely smaller than the warm blooded.

Man - - - - $\frac{1}{12}$ $\frac{1}{15}$ $\frac{1}{30}$ $\frac{1}{15}$
according as he is young or old.

ORANGS.

Long-armed ape, or gibbon - - - $\frac{1}{18}$

SAPAJOUS.

Orange monkey (*simia sciurea*) - - $\frac{1}{12}$
Capucin monkey (*simia capucina*) - - $\frac{1}{15}$
Striated monkey (*simia jacchus*) - - $\frac{1}{18}$
Four-fingered monkey (*simia paniscus*) - - $\frac{1}{11}$

GUENONS.

GUENONS.

Malbrouck (<i>simia faunus</i>) young	-	-	-	$\frac{1}{24}$
The green and red monkeys	-	-	-	$\frac{1}{41}$
Varied monkey (<i>simia mœna</i>)	-	-	-	$\frac{1}{24}$
White eye-lid monkey (<i>simia æthiops</i>)	-	-	-	$\frac{1}{28}$

MAGOTS AND MACAQUES.

Hair-lipped monkey, or macaque	-	-	-	$\frac{1}{96}$
Barbary ape, or magot	-	-	-	$\frac{1}{103}$
Papion, or great baboon	-	-	-	$\frac{1}{104}$

MAKIS.

Ring-tailed maucauco, (<i>lemur catta</i>) young	-	$\frac{1}{61}$
Vari (<i>lemur macaco</i>)	-	$\frac{1}{32}$

CHEIROPTERA.

Great bat (<i>vespertilio noctula</i>)	-	$\frac{1}{96}$
--	---	----------------

PLANTIGRADA.

Mole	-	$\frac{1}{36}$
Bear	-	$\frac{1}{103}$
Hedge-hog	-	$\frac{1}{108}$

CARNIVORA.

Dog	-	$\frac{1}{47}$	$\frac{1}{36}$	$\frac{1}{37}$	$\frac{1}{134}$	$\frac{1}{161}$	$\frac{1}{161}$
Fox	-	-	-	-	-	-	$\frac{1}{103}$
Wolf	-	-	-	-	-	-	$\frac{1}{116}$
Cat	-	-	-	-	-	$\frac{1}{81}$	$\frac{1}{94}$
Panther	-	-	-	-	-	-	$\frac{1}{136}$
Martin	-	-	-	-	-	-	$\frac{1}{103}$
Ferret	-	-	-	-	-	-	$\frac{1}{118}$

RODENTIA.

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RODENTIA.

Beaver	-	-	-	-	-	-	-	$\frac{1}{198}$
Hare	-	-	-	-	-	-	-	$\frac{1}{118}$
Rabbit	-	-	-	-	-	-	$\frac{1}{148}$	$\frac{1}{112}$
Ondatra, or Musk beaver	-	-	-	-	-	-	-	$\frac{1}{114}$
Rat	-	-	-	-	-	-	-	$\frac{1}{78}$
Mouse	-	-	-	-	-	-	-	$\frac{1}{41}$
Field mouse	-	-	-	-	-	-	-	$\frac{1}{31}$

PACHYDERMATA.

Elephant	-	-	-	-	-	-	-	$\frac{1}{388}$
Hogs	Wild boar	-	-	-	-	-	-	$\frac{1}{812}$
	Domestic hog	-	-	-	-	-	$\frac{1}{312}$	$\frac{1}{418}$
	Siamese hog	-	-	-	-	-	-	$\frac{1}{411}$

RUMINANTIA.

Stag	-	-	-	-	-	-	-	$\frac{1}{198}$
Roe, young	-	-	-	-	-	-	-	$\frac{1}{94}$
Sheep	-	-	-	-	-	-	$\frac{1}{111}$	$\frac{1}{194}$
Ox	-	-	-	-	-	-	-	$\frac{1}{888}$
Calf	-	-	-	-	-	-	-	$\frac{1}{219}$

SOLIPEDA.

Horse	-	-	-	-	-	-	-	$\frac{1}{488}$
Ass	-	-	-	-	-	-	-	$\frac{1}{214}$

CETACEA.

Dolphin	-	-	-	-	-	$\frac{1}{11}$	$\frac{1}{16}$	$\frac{1}{88}$	$\frac{1}{104}$
Porpoise	-	-	-	-	-	-	-	-	$\frac{1}{91}$ *

2. Pro-

* To prevent the necessity of returning to this subject in the articles that treat of the brain of the other classes, we shall sub-join

2. *Proportion of the Brain to the Cerebellum
and Medulla oblongata.*

The proportion of the weight of the brain to the cerebellum and medulla oblongata, may be obtained

join a table of its proportion to the rest of the body in some birds and reptiles. It is taken partly from Haller, and partly from our own observations.

BIRDS.

Eagle	-	-	-	-	-	-	-	$\frac{1}{168}$
Falcon	-	-	-	-	-	-	-	$\frac{1}{162}$
Sparrow	-	-	-	-	-	-	-	$\frac{1}{23}$
Canary-bird	-	-	-	-	-	-	-	$\frac{1}{14}$
Siskin	-	-	-	-	-	-	-	$\frac{1}{23}$
Chaffinch	-	-	-	-	-	-	-	$\frac{1}{17}$
Redbreast	-	-	-	-	-	-	-	$\frac{1}{31}$
Blackbird	-	-	-	-	-	-	-	$\frac{1}{28}$
Cock	-	-	-	-	-	-	-	$\frac{1}{15}$
Duck	-	-	-	-	-	-	-	$\frac{1}{237}$
Goose	-	-	-	-	-	-	-	$\frac{1}{366}$

REPTILES.

Land tortoise	-	-	-	-	-	-	-	$\frac{1}{2240}$
Sea tortoise	-	-	-	-	-	-	-	$\frac{1}{5688}$
Collar snake	-	-	-	-	-	-	-	$\frac{1}{792}$
Frog	-	-	-	-	-	-	-	$\frac{1}{172}$

FISHES.

White shark (squalus carcharias)	-	-	-	-	-	-	-	$\frac{1}{2496}$
Great dog-fish (squalus canicula)	-	-	-	-	-	-	-	$\frac{1}{1344}$
Tunny (scomber thynnus)	-	-	-	-	-	-	-	$\frac{1}{37440}$
Pike	-	-	-	-	-	-	-	$\frac{1}{1368}$
Carp	-	-	-	-	-	-	-	$\frac{1}{360}$
Silurus glanis	-	-	-	-	-	-	-	$\frac{1}{1881}$

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obtained with precision, because no variation in the health, corpulence, &c. of individuals, has any apparent influence on these parts.

This proportion is more considerable in man, than in almost all the other mammalia, as will appear from the following table. The Rodentia have the cerebellum largest, in proportion to the brain.

In man, the cerebellum is to the brain,

as	-	-	-	-	-	-	1 : 9
Orange-monkey	-	-	-	-	-	-	1 : 14
Capucin-monkey	-	-	-	-	-	-	1 : 6
Magot	-	-	-	-	-	-	1 : 7
Barbary ape, or Baboon	-	-	-	-	-	-	1 : 7
Varied monkey	-	-	-	-	-	-	1 : 8
Dog	-	-	-	-	-	-	1 : 8
Cat	-	-	-	-	-	-	1 : 6
Mole	-	-	-	-	-	-	1 : $4\frac{1}{2}$
Beaver	-	-	-	-	-	-	1 : 3
Rat	-	-	-	-	-	-	1 : $3\frac{1}{4}$
Moufe	-	-	-	-	-	-	1 : 2
Hare	-	-	-	-	-	-	1 : 6
Wild-boar	-	-	-	-	-	-	1 : 7
Ox	-	-	-	-	-	-	1 : 9
Sheep	-	-	-	-	-	-	1 : 5
Horfe	-	-	-	-	-	-	1 : 7

The proportion of the brain to the medulla oblongata, is estimated by the measure of their diameters. M. Scœmmering and M. Ebel have
6 shewn,

shewn, that this proportion is more in favour of the brain in man, than in all the other animals, and that it is an excellent criterion of the degree of intelligence an animal enjoys; because it is the best index of the pre-eminence which the organ of reflection preserves over those of the external senses. There are, however, some exceptions to this rule; and that which the dolphin affords, is very remarkable.

We subjoin a table of the proportions between the breadth of the medulla oblongata, measured at its base, and the greatest breadth of the brain in some animals.

In man, the breadth of the medulla oblongata, behind the pons Varolii, is to that of the brain as					1 : 7
Short-tailed Macaque	-	-	-	-	1 : 5
Chinese-monkey	-	-	-	-	1 : 4
Dog	-	-	-	-	6 : 11
or	-	-	-	-	3 : 8
Cat	-	-	-	-	8 : 22
Rabbit	-	-	-	-	3 : 8
or	-	-	-	-	1 : 3
Hog	-	-	-	-	5 : 7
Ram	-	-	-	-	5 : 7
Stag	-	-	-	-	2 : 5
Roe	-	-	-	-	1 : 3
Ox	-	-	-	-	5 : 13
Calf	-	-	-	-	2 : 5
					Horse

Horse	-	-	-	-	8 : 21
Dolphin	-	-	-	-	1 : 13*

3. *General Form.*

The differences in the general form of the brain, depend principally on a greater or less magnitude, and development of the two productions of the corpora striata, called the hemispheres; these parts are thicker in every direction, in man, than in any other animal, and hence the peculiar rotundity of his brain.

The brain begins to appear flatter in the monkey kind; their hemispheres are lengthened backward, like those of man, to form the posterior lobes which lie on the cerebellum. In all the other quadrupeds, however, commencing with the Sarcophaga, the hemispheres are not only small, and consequently the fissure which separates them of little depth and the upper surface of the brain flat; but the middle lobes are much less convex inferiorly, and the posterior do not exist at all. The cerebellum appears uncovered behind the cerebrum.

With

* We shall here add a statement of the proportion of the same parts in some birds.

Falcon	-	-	-	-	13 : 94
Owl	-	-	-	-	14 : 55
Duck	-	-	-	-	10 : 27
Turkey	-	-	-	-	12 : 33
Sparrow	-	-	-	-	7 : 18

With respect to the external shape, the brain of monkeys very much resembles that of man, in consequence of its oval form; but in the *Sarcophaga* it is proportionally narrower anteriorly, and approaches more to the triangular shape. This is particularly apparent in the *dog* and the *oppossum*.

Some Rodentia, as the *hares* and the *rabbits*, have also this form; but others, as the *beaver* and the *porcupine*, have the cerebrum almost circular.

In the other herbivorous kinds, the brain is generally of an oval form, broader behind than before.

The cerebrum of the *dolphin* is of a very extraordinary shape; it is very large, and covers the cerebellum superiorly: it is rounded on every side, and almost twice as broad as long.

The cerebellum of man having its middle lobe concealed under the other two, seems at first sight to have no more than two lobes, the general outline of which is nearly round.

In the other animals, even in monkeys, this middle lobe is proportionally larger, and is visible externally. It is equal to the other lobes in the Rodentia: we find it proportionally smaller in the *dolphin* than in monkeys.

4. *Circumvolutions.*

The circumvolutions of the brain are deeper
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in man than in any other animal, and very few have them so numerous.

They are much fewer in the *monkey* kind, particularly in the *sapajous*: the posterior lobe has scarce any, except in the *jocko* and the *gibbon*, in which that lobe is separated from the rest anteriorly, by a very distinct transverse fissure.

In the *Sarcophaga*, the furrows of the brain are pretty numerous, and exhibit a certain order, which is preserved throughout the greater number of species; we observe, posteriorly, two on each side, parallel to the middle line, and a short one anteriorly, which crosses it.

The *Rodentia* have, in general, no sensible circumvolutions; their hemispheres are almost entirely smooth, or exhibit only very slight furrows; but we find a number of convolutions in the hoofed animals, and particularly in the *Ruminantia* and the *horse*.

The *dolphin* has numerous and deep circumvolutions.

All the other mammalia have, like man, the surface of the cerebellum marked by transverse furrows, parallel and adjoining to each other; but they differ amongst themselves with respect to the other furrows, which divide the cerebellum into lobules, and which seem to form circumvolutions similar to those of the cerebrum.

They are somewhat numerous in the *Sarcophaga*, the *Ruminantia*, and the *Solipeda*: we observe fewer in the other orders.

5. *Develop-*

5. *Development of the internal Parts of the Brain in Mammalia.*

The tubercula quadrigemina are proportionally larger in the animals that are removed from man, and are very considerable in the herbivorous kinds, whether Rodentia, Ruminantia, or Solipeda; all these herbivorous animals have the *nates* round, and much larger than the *testes*; this renders it probable that these tubercles were so named by the ancients, in consequence of their being first observed in animals of that order.

In the *monkies*, their respective proportion is nearly the same as in man; but in the *Sarcophaga*, the *testes* are generally larger than the *ovaries*.

In the *dolphin*, they are at least triple the size of the nates.

The tubercles which we have pointed out as forming a third pair in man; become, in the *lemur* and the *dog*, as large as those of the other pairs; but they are very little, or not at all, apparent in the Ruminantia.

The optic thalami, the third and fourth ventricle, and the pineal gland, present no remarkable peculiarities.

The corpora striata do not differ, except a little more or less in breadth. The same observation applies to the corpus callosum and the fornix. The cornua ammonis are in general

proportionally larger in the quadrupeds; there is no swollen appearance on their surface, as in man.

The anterior ventricles have no digital cavity except in man and the monkeys: that part exists in no other mammiferous animal; its presence depends on that of the posterior lobes.

6. *Of the Base of the Brain, and the Origin of the Nerves.*

The base of the brain presents much fewer inequalities in quadrupeds than in man; the infundibulum is not so deep; the middle lobes, and the pons Varolii, are less prominent; the corpora pyramidalia are extended farther backward. With respect to the nerves, we observe no remarkable differences, except in the olfactory.

In the *monkeys* only, the olfactory nerve is, as in man, distinct at its base from the mass of the brain, and forming a medullary filament. In the other animals we perceive only some whitish marks, and, instead of the nerve, a large ashy-coloured eminence, which fills the ethmoidal fossa, and contains a cavity which communicates with the anterior ventricle; this eminence was called, by the ancients, *caruncula mammillaris*.

The *dolphin* has no olfactory nerves, nor any thing that supplies their place. It is the same in several other Cetacea.

It results from these observations, that the peculiar character of the brain of man, and the monkey, consists in the existence of the posterior lobe, and the digital cavity: that of the brain of the Sarcophaga, in the smallness of the *nates*, in proportion to the *testes*; that of the brain of the Rodentia, in the largeness of the *nates*, and in the absence or little depth of the circumvolutions; that of the brain of hoofed animals, in the great size of the *nates*, and the numerous and deep convolutions; that of the brain of Cetacea, in its great height and breadth, and in the total absence of the olfactory nerves. Thus it appears, that all the herbivorous animals have the *nates* larger than the *testes*, and that it is quite the contrary in the carnivorous. Only man, and the quadrumana, have nerves, which, in propriety of language, can be called olfactory. In the true quadrupeds, they are replaced by the carunculæ mammillares; and they are entirely wanting in the Cetacea.

ARTICLE VI.

Of the Brain of Birds.

THE brain of birds is distinguished at the first view, by being formed of six masses or tubercles, all visible externally, viz. two hemi-

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spheres, two optic thalami, a cerebellum, and a medulla oblongata.

The two hemispheres represent the figure of a rounded heart, the point of which is directed forward: the optic thalami are two round tubercles, placed under the hemispheres, but are not enveloped by them: the cerebellum is only a single lobe, compressed laterally: the medulla oblongata has neither corpora pyramidalia nor olivaria, nor pons Varolii; it represents a large smooth surface between the two optic thalami: the crura of the cerebellum pass into it immediately, without forming any projection.

There are no circumvolutions on the hemispheres, nor on the optic thalami; but the cerebellum has some transverse lines parallel, and close together, as in the mammalia.

Birds want the corpus callosum, fornix, and septum lucidum. On separating the two hemispheres, we observe that they are distinct throughout the whole of their height, and that they do not unite to each other except posteriorly towards the anterior commissure of the cerebrum. The surface, by which they join, presents some white radiated lines, which are derived from this commissure; that surface is formed by a thin partition, which serves as the internal parietes to the anterior ventricles. This partition is, as usual, a fold of the appendix of the corpus striatum, which appendix is very small in birds, in which the corpus striatum forms

forms in itself almost the whole of the hemisphere. It takes the figure of a kidney, but has no cauda. The anterior ventricles also are not inflected downward, as in the mammalia, and consequently there is no cornu ammonis. Behind their internal partition there is a fissure, by which they communicate together, and with the third ventricle, if the plexus choroides present no obstacle.

The anterior commissure is prolonged on each side into the substance of the hemispheres, as in man and in quadrupeds.

The third ventricle is situated between the optic thalami; the white lines which bound it superiorly are prolonged, as usual, to form the peduncle of the pineal gland. There is an anterior and posterior commissure which are white.

The bottom of the third ventricle communicates with the infundibulum. Its posterior part communicates likewise with the fourth ventricle, but the arch placed over the aquæduct of Sylvius does not sustain the tubercula quadrigemina. It is a simple thin lamina, which is merely the valvula cerebri extended farther forward.

The fourth ventricle resembles that of mammalia, and has also the longitudinal impression, called calamus scriptorius.

The optic thalami contain each a ventricle which communicates with the others by the aquæductus Sylvii.

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There are no mammillary tubercles or eminences. The corpora striata do not exhibit alternate white and grey striæ internally. The arbor vitæ is less complex than in the mammalia.

Between the corpora striata, and the optic thalami, there are four round eminences which are better distinguished in the *ostrich* than in other birds. The first are situated before the anterior commissure, even in the anterior ventricles. The others are behind that commissure, and project into the third ventricle, nearly at the place where the soft commissure is situated in the mammalia. There is nothing analogous to these tubercles in the human brain, but we find similar ones in that of fishes.

The olfactory nerves arise from the point of the hemispheres, and do not come from their base as in the mammalia; they appear to be a mere continuation of these bodies.

The other nerves of the brain do not differ in their origin.

ARTICLE VII.

Of the Brain of Reptiles.

ALL the parts of the brain of reptiles are smooth, and without circumvolutions. The
optic

optic thalami are situated behind the hemispheres, but are not covered by them. They contain each, as in birds, a cavity which communicates with the third ventricle. At the extremities of this ventricle, we observe the anterior and posterior commissure, but there is no soft commissure, nor tubercula quadrigemina.

In the *tortoise* the hemispheres form an oval. Their anterior part is separated from the posterior by a sulcus, and represents a kind of bulb, which serves as a root to the olfactory nerves. The size of this bulb is about equal to one-third of the hemisphere. The interior of the hemisphere is, as usual, excavated by a ventricle, and contains a substance analogous to the corpus striatum, and which pretty much resembles in its form that of birds.

The optic thalami are not larger than the bulbs of the olfactory nerves. Their form is nearly round. They extend downward and forward, under the hemispheres, to produce the optic nerve. The valve of the cerebrum is situated between them and the cerebellum. No tubercle is either placed above it or before it, and it gives origin, as usual, to the fourth pair of nerves.

Before the optic thalami, and under the posterior part of the hemispheres, there is a tubercle which corresponds to that we have remarked in birds.

The cerebellum is nearly hemispherical. The
fourth

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fourth ventricle penetrates a considerable way into its substance.

In the *frog* the hemispheres are longer and narrower. The optic thalami are larger in proportion to the hemispheres. Their ventricle is very distinct. It is the contrary in *salamanders*, which have the optic thalami very small, and the hemispheres almost cylindrical.

The cerebellum of these two kinds of reptiles is flat, triangular, and lies posteriorly on the medulla oblongata.

In the *serpents* the two hemispheres form together a mass which is broader than long. The optic thalami are almost round, and one half less than the hemispheres behind which they are situated. The olfactory nerve has no apparent bulb. The cerebellum is exceedingly small, flat, and in the form of a portion of a circle.

In all these animals the inferior surface of the brain is nearly smooth. The optic thalami make no projection downward, and the pons Varolii does not exist.

The olfactory nerves arise, as in birds, from the anterior extremity of the hemispheres. The optic nerves seem to derive their origin from a common eminence, situated under the middle of the hemispheres. The other nerves exhibit no particularities as to their origin.

ARTICLE VIII.

Of the Brain of Fishes.

THE different lobes and tubercles which compose the brain of fishes, are situated behind each other, in such a manner that the whole, instead of appearing as one common mass, more or less, approaching an oval form, resembles a kind of double chaplet. This comparison is more properly applied to the brains of fish, than to those which we have just noticed, on account of the greater number of those tubercles or lobes.

The cerebellum is always single. It is proportionally larger than in warm-blooded animals. It even frequently surpasses the hemispheres in size.

The two hemispheres always exist. They are generally of an oval form, without any apparent circumvolution, and each contains a ventricle, the floor of which presents an elevation analogous to the corpus striatum.

The optic thalami are constantly situated, as in birds, below the hemispheres. They are smaller than the latter, but each of them also contains a ventricle.

On the two sides of the origin of the médulla oblongata, behind the cerebellum, there are almost always some tubercles, which appear to form

form the origin of several pairs of nerves, and which are often as large as the hemispheres. There is sometimes a single tubercle between them, which seems to form a second cerebellum.

The olfactory nerves, at their origin, form swellings or knots, the number of which varies, and which are frequently so large that some authors have mistaken them for the real brain.

Finally, in several fishes there are under the common arch of the hemispheres, sometimes two, sometimes four tubercles, which vary in their figure and proportions, but which would present a striking analogy to the tubercula quadrigemina, were they not like those that resemble them in birds, situated before and above the optic thalami.

The brain of fishes is always very small in proportion to their body. It never completely fills the cavity of the cranium. The surface of the hemispheres is always smooth. The cerebellum and its lateral tubercles occasionally appear rugous.

The brain may vary in the different kinds of fishes. 1st. In the number and form of the tubercles of the olfactory nerve. 2. In the number and form of the eminences contained within the hemispheres. 3. In the form of the cerebellum. 4. In the tubercles which are situated behind the cerebellum. We proceed to examine it under these different points of view.

1. *The*

1. *The Tubercles of the Olfactory Nerves.*

In the *rays* and the *sharks* the tubercles are united into one mass of various lengths, but which is more than double the size of the hemispheres. It contains no cavity, and its inside is entirely formed of a homogeneous medullary substance. The olfactory nerve, properly so called, arises from each of the lateral parts of this mass, which several authors have described as the cerebrum, and others as its anterior lobes.

These tubercles are long and narrow in the *sturgeon*: they are simple, oval, and smaller than the hemispheres in the *lump fish* and the *moon fish* (*Tetrodon mola* Lin.) The genus *gadus*, that is to say, *cod*, *whitings*, &c. have them simple and round. In the *cod* they are even almost as large as the hemispheres. The *wrasses*, and all the genus *cyprinus*, that is to say, *carps*, *barbels*, *tenches*, &c. have them also simple and round, but distinguished by a slight furrow, which gives them the form of a kidney. In the *pleuronectes*, the *berrings*, the *piques*, the *perches*, and in all the *salmon* genus, which includes the *trouts* and the *smelts*, &c. there are two pair of tubercles, the anterior of which is smaller than the other, but they do not equal the hemispheres in magnitude. Finally, in the *eel* genus there are three pair of tubercles, which diminish in magnitude, beginning with the last. Their brain therefore presents altogether ten eminences before the cerebellum,

bellum, eight of which are superior, viz. the six tubercles, and the two hemispheres; and two inferior, which are the optic thalami.

2. *The Eminences within the Hemispheres.*

a. The corpora striata are not apparent in the *rays* and *sharks*, and the interior of their ventricle presents no eminences. In most of the other fishes the corpora striata represent two segments of a circle, the concavity of which is turned inward. From the convex side some very fine medullary striæ proceed, which are prolonged transversely on the internal parietes of the ventricle. These corpora striata vary in breadth according to the species. They form two elevated oval bodies in the *whiting*. Their anterior extremity approaches nearer to the middle line than the posterior. The anterior commissure of the brain is situated a little below them. Between them we observe a fissure, which leads into the third ventricle. The superior portion of each hemisphere is not, as in the other red-blooded animals, an appendix of the corpora striata, which bends inferiorly to form a vault.

b. The tubercles, similar to the quadrigemina, do not exist in the *rays* and the *sharks*. There is only a single pair in the *eels*, the *haddock*s, and the *herrings*, which produces a semi-oval eminence before the cerebellum, between the
posterior

posterior extremities of the corpora striata. The *pikes*, the *trouts*, and *salmon*, and the *perches*, have two pairs, which form four round small tubercles, the posterior of which are rather the largest.

In the *carp* genus there are also four eminences, but they are very unequal. The posterior are small and round, the anterior are extremely long, cylindrical, and bent outward and backward, following the curvature of the lateral ventricles, all the cavities of which they occupy. Their posterior surface is marked by a longitudinal furrow.

3. *The Cerebellum.*

The cerebellum of fishes does not merely cover the fourth ventricle; that cavity rises into its substance: it is sometimes rounded, and sometimes approaches more or less to a conical form. In the *rays* and the *sharks* it is irregularly furrowed. It is smooth in almost all the other fish. Internally, we observe no vestiges of the arbor vitæ, except some indistinct whitish lines. Where its form is conical, as in the *cod* and the *carp*, its point is inflected a little backward, which gives it the form of a Phrygian cap.

4. *The Tubercles situated behind the Cerebellum.*

These tubercles are peculiar to fishes, unless

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we regard them as supplying the place of the corpora olivaria.

In the *ray* they are large, irregularly furrowed, and evidently give origin to the greater part of the fifth pair of nerves.

The *carp* has them as large as the hemispheres, and in the form of kidneys. Between them there is a large round tubercle, which may be called a second cerebellum, but which is immediately connected with the dorsal part of the medulla oblongata, and which encloses no ventricle.

In the *whiting* and the *cod* the tubercles are oval, and situated altogether above the medulla. It is nearly the same in the *common eels* and *conger eels*.

These parts are little apparent in the *pikes*, *trouts*, *salmon*, and *perches*.

5. Origin of the Nerves.

In fishes the olfactory nerves are merely continuations of the tubercles situated before the hemispheres. They frequently take a long course before they arrive at the nostrils. The optic nerves arise under the cerebrum where the thalami are situated. These nerves are very large, and are composed either of distinct filaments, or of a single flat band which is sometimes folded longitudinally on itself. They cross without being confounded, and we plainly see

see that the nerve of the left side proceeds to the right eye, and that of the right side to the left.

The fifth pair of nerves arise so near the auditory that they seem but one. The fascial nerve, on the contrary, is very distinct from the auditory. The nerve of the eighth pair is very thick; the others present no peculiarity.

ARTICLE IX.

Recapitulation of the Characters peculiar to the Brain in the Four Classes of Vertebral Animals.

FROM the examination we have just concluded, it results,

1. That the character which distinguishes the brain of mammalia from that of the other red-blooded animals, consists,

a. In the existence of the corpus callosum, the fornix, the cornua ammonis, and the pons Varolii.

b. In the tubercula quadrigemina being placed upon the aquæductus Sylvii.

c. In the absence of ventricles in the optic thalami, and in the position of these thalami within the hemispheres.

d. In the alternate white and grey lines within the corpora striata.

2. The character peculiar to the brain of birds consists,

a. In the thin and radiated septum, which shuts each anterior ventricle on the internal side.

3. The character of the brain of reptiles depends,

a. On the position of the thalami behind the hemispheres.

4. The character belonging to the brain of fishes consists,

a. In the tubercles of the olfactory nerves, and the tubercles situated behind the cerebellum.

5. The three last classes have, in common, the following characters, by which they are distinguished from the first:

a. Neither corpus callosum, nor fornix, nor their dependencies.

b. Some tubercles, more or less numerous, situated between the corpora striata, and the optic thalami.

c. The thalami containing ventricles, and being distinct from the hemispheres.

d. The absence of any tubercle between the thalami and the cerebellum, as well as the absence of the pons Varolii.

6. Fishes have certain characters in common with birds, which are not to be found in the other classes: these are,

a. The

a. The position of the optic thalami under the base of the brain.

b. The number of the tubercles placed before these thalami, which are commonly four.

7. Fishes and reptiles have for a common character distinguishing them from the two first classes, the absence of the arbor vitæ in the cerebellum.

8. All red-blooded animals have the following characters in common :

a. The principal division into hemispheres, optic thalami, and cerebellum.

b. The anterior ventricles double, the third and fourth single, the aquæductus Sylvii, the infundibulum, and a communication between all these cavities.

c. The corpora striata and their appendices in the form of a vault, called hemispheres.

d. The anterior and posterior commissures, and the valve of the cerebrum.

e. The bodies named pineal and pituitary glands.

f. The union of the great single tubercle or cerebellum, by two tranverse crura, with the rest of the brain, which gives origin to the two longitudinal crura of the medulla oblongata.

9. It also appears that there exist certain relations between the faculties of animals and the proportions of their common parts.

Thus the intelligence they possess, appears more perfect in proportion to the volume of the

appendix of the corpus striatum, which forms the vault of the hemispheres.

Man has that part greater, more extended, and more reflected than the other animals.

In proportion as we descend from man, we observe that it becomes smaller and smother on the surface, and that the parts of the brain are less complicated with each other, but seem to be unfolded and spread out longitudinally.

It even appears that certain parts assume, in all classes, forms which have a relation to particular qualities of animals: for example, the anterior tubercula quadrigemina of *carps*, which are the most feeble and least carnivorous of fishes, are proportionally larger than in the other genera, in the same manner as they are in the herbivorous quadrupeds. By following these inquiries, we may hope to obtain some knowledge of the particular uses of each of the parts of the brain.

ARTICLE X.

Of the Membranes of the Brain.

IN all the red-blooded animals, the brain, as well as the other parts of the nervous system, is covered by three membranes.

That which is next to it, is named the *pia-mater*;

mater; the external is called the *dura-mater*; and that which is intermediate, has been denominated *arachnoides*.

a. The *dura-mater* is a thick opaque membrane, which lines all the osseous cavity of the cranium, and the vertebral canal.

The greater part of the fibres of the external surface are longitudinal, and most of those of the internal surface are transverse; but a considerable number of others run in various directions.

Within the cranium the *dura-mater* is intimately united to the bones, and supplies the place of the periosteum. Its external surface is cellular and flocculent: its internal is smooth and glossy. In the vertebral canal it is more loose, and is not intimately united to the bones; but its organization is the same. This membrane is regarded by anatomists as formed of two laminæ, though it is extremely difficult to separate them. Blood vessels are distributed between these laminæ, and the internal appears to be detached from the external, to form several reflections.

Seven of these reflections have been described in man.

1. The *falx of the cerebrum*, which extends from the crista galli of the ethmoid bone, to the internal spine of the os occipitis. Its inferior edge is unattached. It is narrow anteriorly, broad posteriorly, and is situated between the

two hemispheres, which it separates from each other.

2. The *tentorium cerebelli*, which separates the two posterior lobes of the cerebrum from the cerebellum. It arises from the dura-mater, before the two branches of the occipital cross, and extends towards the posterior clinoid processes, leaving a vacancy for the passage of the medullary prolongations of the cerebrum.

3. The *falx of the cerebellum*, which corresponds to the inferior line of the occipital cross, and is extended some way between the lobes of the cerebellum.

4. The two folds which pass from the anterior to the posterior clinoid processes, and in that manner circumscribe the pituitary fossa.

5. Finally, the two reflections which separate the anterior from the middle lobes of the cerebrum, and surround the orbital processes of the os sphenoides, called the little wings of Ingraffias.

In the other mammalia, the falx of the cerebrum diminishes greatly both in length and breadth.

The *tentorium cerebelli*, on the contrary, is very considerable: it is even supported by an osseous lamina in those that run swift, as we have pointed out in the Osteology of the Head, Art. 3. This fold seems destined to prevent the friction of the two parts of their brain, in the same manner as the falx of the cerebrum prevents

vents the one hemisphere from pressing on the other, when the head repofes on one fide.

The falx of the cerebellum difappears entirely in all animals in which the vermiform procefs projects more than the lateral lobes, as is the cafe in all the real quadrupeds.

We find the falx of the cerebrum in birds. In the *turkey* it has the form of the fegment of a circle: it extends from the middle fpace between the openings for the olfactory nerves, to the tentorium of the cerebellum. The falx of the cerebellum is wanting. The tentorium, which is not extenfive, is fufained by an offeous lamina, and there are befides two particular folds on each fide which feparate the hemifpheres from the optic thalami.

None of thefe folds are found in the animals that have cold red blood. The dura-mater of reptiles and fifhes adheres in every part to the internal furface of the cranium: it is even feparated from the brain by a mucous or oily fluid of more or lefs confiftence.

b. The *membrana arachnoidea* is thus named from its texture, which is extremely delicate and tranfparent, and which has therefore been compared to that of a *fpider's* web: it envelopes the pia-mater, but does not penetrate with it into the furrows of the brain: it is fretched over thefe depreffions in the manner of a bridge, except at fome places where the internal lamina of the dura-mater is prolonged: it makes a large fun-

nel, which receives the medulla spinalis. In man this sac appears to commence immediately below the origin of the optic nerve.

The cold-blooded animals in which, as we have already observed, the brain does not fill the cavity of the cranium, have the arachnoides replaced by a lax cellular substance, which occupies all the space included between the dura and pia-mater; it is commonly moistened by a gelatinous fluid, as in the cartilaginous fishes, and sometimes coloured with blood. In the *carp* and the *salmon* this humour appears like an oily froth.

c. The *pia-mater* is the membrane which immediately envelopes the substance of the brain; it descends into all the furrows that appear on its surface, and which form its circumvolutions. It would appear to consist altogether of blood-vessels, but the arteries and veins only pass through it. We observe that it is much more solid, and has a greater number of vessels at those places where it covers the cineritious parts of the brain, than where it envelopes the medullary substance and the nerves: it accompanies and invests the *spinal marrow*; it penetrates into the several ventricles, but is not attached to their parietes; it floats in their cavity where it supports the vessels. These productions are called *plexus choroides*.

The processes of the pia-mater, which are reflected between the convolutions, are attached

to the brain by a fine cellular structure, which appears to be formed by blood-vessels of an extreme tenuity.

In mammiferous animals the greatest prolongation of the pia-mater is found in the part of the anterior ventricles corresponding to the lower edge of the fornix, and the superior of the optic thalami. It is a vascular web, folded on itself, and forming a kind of cord. When extended, its figure is nearly triangular: the vessels which penetrate it are very closely interlaced on the edges of this web, and those parts have more particularly received the name of plexus choroides. There is a plexus similar to the middle of the inferior surface of this web, placed exactly upon the aperture of the third ventricle.

In birds there are two narrow bands which pass into the ventricles, and occupy the whole of their length.

There is also an analogous structure in fishes; but the plexus adheres to the parietes of the ventricles, and does not float within them.

We find two other productions of the pia-mater, in the fourth ventricle, situated under the cerebellum, one on each side. They appear to be unattached.

They are wanting in birds.

ARTICLE XI.

Of the Vessels of the Brain.

IN man, six principal arteries enter the cranium, three on each side: one is distributed to the dura-mater, and is called *arteria spheno-spinalis*; the other two, which extend to the brain, are named *arteria carotis interna*, and *arteria vertebralis*.

The *spinal artery* is a branch of the internal maxillary, and passes into the cranium, through the small foramen of the posterior process of the os sphenoides. Upon reaching the interior of the cranium, it ascends towards the internal surface of the parietal bone; it there spreads upon the body of the dura-mater, by a great number of ramifications, which anastomose together in a manner which may be compared to the nervures of a fig leaf.

This arrangement is the same in all the mammalia.

The *internal carotid artery* comes forth from the osseous conduit of the temporal bone, and proceeds for some time involved by the dura-mater, and bathed in the venous blood contained in the cavernous sinus: it afterwards passes into the cranium behind the anterior clinoid processes; it is then named *arteria cerebialis*: it distributes several small ramifications to
the

the adjacent parts, and always sends off a large branch posteriorly, which is united with the trunk of the vertebral arteries, and is named *arteria communicans*.

Two small branches, which extend to the plexus choroides, usually arise from the cerebral artery when it has furnished the *communicans*. The trunk is afterwards bifurcated; and one of the branches goes forward above the corpus callosum, whence it is named *arteria callosa*. Like all the other branches, it gives off a number of ramifications to the neighbouring parts: the other branch is somewhat larger than the former; it is directed outward to the surface of the hemispheres, into the pia-mater, and fissure of Sylvius, where it is divided and sub-divided without end, in order to be conveyed by extremely minute vessels, even into the substance of the brain.

The *vertebral arteries*, after suffering numerous inflexions in the canal formed by the holes with which the five intermediate vertebræ of the neck are perforated, pass into the cranium through the foramen magnum; they then go forward into the basilar fossa of the os occipitis, where they unite into one common trunk, called *arteria basilaris*; but they previously detach two branches to each side of the pons Varolii, which ramify upon the inferior surface of the cerebellum: one of these ramifications is denominated *spinalis posterior*, because it penetrates
the

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the fourth ventricle, and accompanies the medulla spinalis posteriorly, as far as the lumbar vertebræ. The same vertebral arteries furnish the *spinales anteriores*; these unite towards the great hypoglossal nerves, into a single trunk, which runs down the vertebral canal on the fore part of the spinal marrow, to the os sacrum, sending off a number of small branches, which anastomose with other arteries.

The basilar trunk is again bifurcated to produce the *arteriæ superiores cerebelli*, situated between the cerebrum and cerebellum, and also the *arteriæ communicantes*, which, as we have already shewn, are united with the carotids.

There are no large trunks formed by the veins of the brain; they open into conduits of a particular nature, called *sinuses*; these are formed by duplicatures of the dura-mater, attached to the bones by strong cellular substance, and provided internally with a compact texture and ligamentous fræna. The veins are inserted into them in a manner contrary to the course of the blood. The object of this organization appears to be, to prevent the reflux of the venous blood, which might affect the brain.

All the sinuses disgorge the blood they contain, either directly or mediately, into a dilated part called the fossa of the *jugular veins*: this fossa is situated above the posterior foramen lacerum, by which the vein passes out of the cranium.

The

The sinuses of the human brain are, the *posterior longitudinal*, which extends along the convex edge of the falx; the *inferior longitudinal*, situated on its concave edge; the *straight*, which proceeds from the posterior extremity of the preceding, and opens into one or other of the *lateral sinuses*: the lateral are distinguished into the right and the left; the one commonly receives in itself alone the blood from the superior longitudinal sinus; the other usually receives that which is contained in the right sinus: each on its respective side follows the sulcus, traced between the cerebrum and cerebellum, to the base of the os petrosum, along the posterior edge of which they descend into the jugular fossa.

The *circular sinus* of the *sella turcica* surrounds the pituitary gland; it empties itself into the two great reservoirs, situated on the sides of the sella; called the *cavernous sinuses*, in which the carotid artery, and several pairs of nerves, are contained. A venous conduit, which extends from the cavernous sinus to the jugular fossa, is named the *inferior petrous sinus*. Lastly, we distinguish, under the name of the *superior petrous sinus*, another small conduit, which accompanies the projecting angle of the os petrosum, and which opens into the right sinus.

The blood-vessels within the cranium of other mammiferous animals, do not differ from those of man, except in their position. In the eighth

Lecture we have pointed out the cavities of the interior of the cranium, and the furrows traced upon it, as these furrows are impressions made by vessels; they indicate to a certain degree the directions of those vessels: thus, by the description of the carotid canal, and the spinous and vertebral foramina, we are made acquainted with the points from which the arteries proceed. Those of the brain are disposed nearly as in man: but they assume other curvatures, which are determined by the form of the lobes.

There is, however, a particular arrangement of the vessels around the carotid artery, just at the part where that vessel passes into the cranium: this is what the ancient anatomists called *rete mirabile*, or *wonderful plexus*. It was formerly supposed that this disposition of vessels existed in man; but it is now well known to prevail only in a certain number of animals. The following is its most usual distribution: the *rete mirabile* is the produce of arterial ramifications, which proceed from the carotid artery, and which surround the pituitary gland: all these minute branches, in which the artery seems to be as it were dissolved, are re-united anew into one trunk. This at least appears to be the case in the greater number of the *Sarcophaga*. The *elephant* and the *beaver* do not present this arrangement of vessels.

The arterial and various vessels of birds are analogous to those of mammalia; but we have
not

not yet examined them accurately. We propose, however, to direct our enquiries to that subject, both in them and in reptiles.

In fishes, particularly in the cartilaginous kind, as *rays*, *sharks*, &c. the arterial vessels of the brain proceed from two recurrent trunks, of the first pair of branchial veins: these two arteries ascend forward towards the cranium, which they penetrate inferiorly, near the point of its union with the vertebral column. Having reached the cavity of the cranium, they divide each into three branches, one of which descends into the vertebral canal, to be united to its correspondent of the other side, and to a small middle trunk, of which we shall speak hereafter. The union of those three branches forms a large artery, which accompanies the spinal marrow inferiorly, and may be named the *spinal artery*. A number of ramifications separate from it, which follow the course of the nerves. The second branch of the vertebral artery extends obliquely forward, under the medulla spinalis; it there meets the middle trunk, and the corresponding branch of the other side. The third branch of the vertebral artery is more anterior; having arrived at the root of the medulla spinalis, it sends off two branches, which extend to a vascular ring, produced by the middle vessel, which runs across it, so as to form a kind of *capital Greek phi* ϕ , accompanied with two semi-circles affixed to it

in

in opposite directions, thus OFC . The branch still continues to advance until it reaches the nerves of the eighth pair; it there detaches two new trunks, which being rejoined, form the commencement of the middle vessel, which we have several times mentioned, and which terminates by producing the spinal artery, following in this manner the inferior line of the brain: the anterior branch continuing its direction forward, furnishes a number of small arteries to the cerebrum; it passes under the origin of the nerve of the fifth pair, and finally arrives under the olfactory tubercle, where it expands, like the foot of a goose, and surrounds it on every side.

Such are all the principal branches in the brain of fishes: the venous vessels are also very numerous, and are distributed into the greasy or mucous liquor which covers the brain; they are not, however, sufficiently known to us to enable us to describe them.

ARTICLE XII.

Of the Medulla Spinalis.

THE elongation of the brain, which comes out of the cranium by the foramen magnum, has
been

been named *Medulla Spinalis* : it appears to be formed, as we have already shewn, by the union of the two medullary productions of the cerebrum and cerebellum.

The spinal marrow appears externally to be entirely composed of a white substance, but assumes a greyish tinge internally. Covered with its membranes, it has more consistence than the brain, but it liquifies almost as soon as the envelope is removed. The form of this medullary prolongation, is that of a cylinder, somewhat compressed ; it seems to be composed of two cords, divided by two furrows, one on the side of the body of the vertebræ, and the other on that of its spinous process : on separating a little the edges of these furrows, we observe fibres which seem to cross each other, and unite the two fasciculi of the medulla ; its thickness varies in different parts of the canal through which it passes. In general, the diameter of the spinal canal is greatest in the inferior part of the neck. In this place the medulla spinalis is also largest : it again experiences a kind of enlargement towards the last dorsal vertebræ. In the lumbar region it contracts, and becomes conical, and finally terminates in a filament, which belongs to its envelope, and which is placed at the extremity of the vertebral canal. The structure is nearly similar in all the red-blooded animals.

The medulla spinalis gives origin to as many
 Vol. II. O pairs

pairs of nerves as there are holes between the vertebræ; these nerves receive names from the region of the spine whence they proceed.

The cervical nerves are seven in number in most of the Mammalia; the three-toed sloth and the Cetacea excepted. In birds this number is much greater. It is usually smaller in the reptiles, and frequently there are none in fishes.

The nerves of the other regions likewise vary exceedingly: but we adduce no more examples here, because they would be only repetitions of what we have stated in Lect. III. Art. 1.

The origin of all the vertebral nerves is nearly similar; they appear to be produced by two roots, one of which arises before and the other behind the medulla. These two roots are separated from each other by a membranous production, which we shall notice when we treat of the membranes of the medulla spinalis. The nervous roots issue from the vertebral canal by two distinct holes which perforate the dura-mater before the intervertebral foramina. They afterwards unite and form a ganglion that produces the vertebral nerves, which we shall describe in the next Lecture.

1. *Vessels of the Medulla Spinalis.*

The arteries of the medulla spinalis are numerous: two are furnished by the vertebrales; one posterior and the other anterior, which are
distin-

distinguished under the name of *spinales*: they are distributed in the pia-mater, and several minute ramifications penetrate into the substance of the medulla itself. The others proceed from the cervical, intercostal, lumbar, sacral and coccygeal arteries. They enter the canal by the holes through which the nerves pass out of it, and communicate with other arteries, and with each other, by a number of very fine anastomoses.

The veins of the medulla spinalis are also very numerous. Their small ramifications extend through the pia-mater, and empty themselves into two longitudinal sinuses of the dura-mater that invests the vertebral canal; these two sinuses are united by veins which have transverse communications corresponding to each of the *vertebræ*. The first of these communicating branches discharges the blood into the jugular fossæ: the others empty themselves in the following manner, *viz.* the cervical into the vertebral vein; the dorsal into the intercostal veins; and finally, the lumbar and sacral into the veins of the same name.

2. *Membranes of the Medulla Spinalis.*

In the article on the envelopes of the brain, we observed that the membranes of that viscus are prolonged into the spinal canal, and cover the medulla spinalis. The whole is contained in the osseous canal formed by the *vertebræ*, the number and articulations of which vary consi-

derably, as we have already shewn in the third Lecture, when we described the bones of the spine. We then omitted the structure connected with the passage of the nerves, and shall now proceed to notice it.

The annular part of each vertebræ has a notch, which is situated inferiorly in the lumbar and lowest dorsal vertebræ. It is common to both edges of the adjacent vertebræ in the first dorsal, and in the cervical. There is only a simple hole in the odontoid or second cervical vertebræ.

This is the manner in which the nerves issue in the greater number of Mammalia and birds, and even in the crocodile. Some quadrupeds, however, as the *horse*, have holes instead of notches. As the annular parts do not touch each other in fishes, they have neither holes nor notches.

The pia-mater has a peculiar formation in the interior of the vertebral canal; it is prolonged from each side of the medulla, between the roots of the vertebral nerves, in such a manner as to make as many denticulations as there are pairs of nerves. This duplicature of the pia-mater has obtained the name of *Ligamentum denticulatum*: it commences about the margin of the foramen magnum, and its denticulations terminate towards the first lumbar vertebræ; it is there confounded with the pia-mater, to which it is applied. The same disposition prevails in Mammalia and birds.

LECTURE TENTH.

DISTRIBUTION OF THE PRINCIPAL NERVES
IN ANIMALS WITH VERTEBRÆ.

THE central part of the nervous system was described in the last Lecture: we now proceed to follow its branches in their distribution to the different parts of the body.

The most remarkable circumstance this distribution presents, is the fidelity with which Nature follows one general plan, from which she departs as little as possible in the different species of animals.

This constancy, of which we have already had repeated proofs in the skeleton, and the muscles, is still more remarkable in the nerves, though at first sight it appears less necessary.

Analogous parts always receive their nerves from the same pair in all animals, whatever be the position of those parts, or however circuitous the course of the nerve may be in order to arrive at them. Analogous nerves have always a similar distribution: they proceed uniformly to the same parts: even the smallest pairs, the purposes of which are most limited, and which might be most easily supplied by adjacent nerves, as the fourth and the sixth pairs, preserve their existence and their proper uses.

From this observation it seems reasonable to conclude, that the nerves are not entirely similar to each other, and are not like the arteries, every where the conductors of a fluid perfectly the same; but that there is, in the structure, mode of action, and secretion of each, some peculiarity relative to the functions and nature of the organ to which they are distributed.

This is the principal consideration, which renders the detailed comparison of the nerves in the different classes interesting to the physiologist.

ARTICLE I.

Of the Olfactory Nerve, or the First Pair of the Brain.

A. In Man and other Mammiferous Animals.

WE have pointed out the manner in which the olfactory nerve arises in Man, in the Mammalia, and in the other classes of red-blooded animals; we shall now follow it through the cavity of the cranium, until it enters the organ of smell.

In man, when the olfactory nerve has reached the inferior surface of the brain, it proceeds forward above the membrana arachnoidea. It gradually approaches the nerve of the opposite side; and,

and, when they arrive at the cribriform lamella of the os ethmoides, the two nerves are separated from each other only by the falx of the cerebrum. In this course the nerve is received in a slight furrow of the anterior lobe. When taken out of the furrow, it appears triangular. It is terminated anteriorly by a small and very soft tubercle of a cineritious colour, the fibres of which enter the nasal fossæ by the holes which pierce the cribriform lamella of the os ethmoides.

These nerves have nearly the same disposition in the *monkey* kind as in man; but those are the only animals that present them distinct, and in an elongated form. In all the other families, instead of the whitish cord which constitutes the olfactory nerve, we perceive only a large ash-coloured eminence which fills the ethmoidal fossæ. This medullary part is hollow, and communicates with the cavity of the anterior ventricle. To this singular disposition we must attribute the ignorance in which anatomists have so long continued respecting the olfactory nerve, and the error which induced the antients to conclude that these nerves, which they called *processus* or *carunculæ mammilares*, were the conduits which conveyed the pretended *pituita* of the brain into the cavity of the nostrils.

Amongst Mammalia, the *porpoises* and the *dolphins* have no olfactory nerves. It is probable that the other Cetacea likewise want them, as they have no ethmoidal holes.

B. *In Birds.*

The olfactory nerve of birds, after separating from the brain in the manner we have described, passes into an osseous canal, where it is accompanied by a vein, and thus reaches the cavity of the nose.

C. *In Reptiles.*

This nerve proceeds to the nostrils in this class nearly in the same manner as in birds; but it is longer. The canal which receives it is partly osseous and partly cartilaginous. The two canals have only one common aperture within the cranium. The olfactory nerves of reptiles are generally much more solid than those of the preceding classes.

D. *In Fishes.*

Cartilaginous fishes, as the *ray* and the *sharks*, have the olfactory nerve very soft. It is in them a bulb, which passes obliquely forward towards the nares, which are at a greater or less distance from the brain according to the species. In the *galeated shark* or *tope*, the nerve which is at first slender, afterwards enlarges, and forms a gross ganglion. In the *lesser dog-fish* (the *squalus catulus* of Linnæus) the nerve has much resemblance to that of the greater number of the Mam-

Mammalia. It is thick, short, tubular, and surrounded with an ash-coloured substance. It is terminated by a semilunar ganglion, which is separated from the nostril by a membranous septum. This septum contains various depressions, each of which is perforated by several holes, which afford a passage for the nervous ramifications into the membranes.

The spinous fishes have the olfactory nerves very long and slender. In those which have the snout elongated, this nerve is received into a cartilaginous tube. In those with short noses the nerve is surrounded by only a fine membrane, which appears to be the same as that which contains the fat or oily humour that covers the brain.

In most of these fishes the nerve is of equal breadth in its different parts. The genera *cyprinus* and *gadus*, however, have it enlarged at the nasal extremity into a round ganglion, which resembles the cup of an acorn.

ARTICLE II.

Of the Optic Nerve, or the Second Pair of the Brain.

IN this article we shall describe the course of the optic nerve, merely from the point where it
sepa-

separates from the correspondent nerve after decussation, until it enters the globe of the eye to form the retina. We shall treat of its termination in the Lecture on Vision.

In all red-blooded animals, without exception, the optic nerve arises, as we have already shewn, from a particular tubercle of the brain. After crossing the correspondent nerve, it proceeds directly to the eye on the opposite side.

In mammiferous animals, birds and reptiles, it is very difficult to distinguish these nerves at their union: but in fishes, particularly in those that have an osseous skeleton, it manifestly appears that these nerves cross each other without being confounded. They are in fact connected to each other by cellular substance. We observe, and very easily demonstrate, that the optic nerve of the left side proceeds to the right eye, and *vice versa*. In the cartilaginous fishes this decussation is less apparent.

The optic nerve of large animals exhibits a very remarkable structure. Its neurilema, or the envelope furnished to it by the pia-mater, divides it internally into a great number of longitudinal canals which contain the medullary substance. This structure is rendered very apparent, when the medullary substance is dissolved by maceration, and the nerve inflated and dried.—Sections of this nerve, thus prepared, demonstrate the arrangement of the canals which traverse it.

These

These nervous filaments are, however, more separate in the optic nerves of fishes, in which they can be demonstrated without any particular preparation. They are commonly flat like the other nerves, and sometimes appear to be formed by a very thin medullary lamina, which is folded several times on itself, and contracted into the figure of a cord. This is particularly the case in the *cod* and the *sword fish*.

ARTICLE III,

Of the Nerves of the Third, Fourth, and Sixth Pairs.

1. Of the Oculo-Muscular Nerve, or the Third Pair.

AFTER entering the dura-mater at the side of the posterior clinoid process, each of these nerves passes in the substance of that membrane until it reaches the broadest part of the sphenoid-orbital fissure. When arrived in the orbit, the nerve divides into two branches; one, which is small, is distributed to the muscles called rectus superior oculi, and levator palpebræ superioris. It frequently contributes to the formation of the ophthalmic ganglion which produces the ciliary nerves. The other branch is somewhat more
con-

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considerable. It divides into three ramifications; one is sent to the abductor oculi, another into the rectus inferior, and the third terminates in the obliquus major.

This brief description of the oculo-muscular nerve in man, may be applied to almost all red-blooded animals. In all of them it passes into the orbit by a particular hole, when there is no spheno-orbital fissure, either singly, or accompanied by some of the other nerves appropriated to the organ of vision, and is distributed in the same manner. We shall, however, have occasion to return to this nerve, and those that follow it, when we treat more particularly of the eye. We shall merely remark here, that in the *rays* and the *sharks*, in which the globe of the eye is supported upon a moveable peduncle, one of the branches of the oculo-muscular nerve passes across that cartilaginous peduncle, by a particular hole, in order to be distributed in the muscles situated below it.

2. *Of the Pathetic Nerve, or the Fourth Pair.*

These nerves pierce the dura-mater behind the preceding, and a little more towards the middle line. They are more slender than the nerves which issue from the base of the cranium. Lodged in the folds of the dura-mater, they extend towards the superior orbital fissure, and pass into the orbit by the widest part of it;
then

then turning towards the roof of the orbit, they terminate in the obliquus major.

The distribution of this nerve is the same in most of the red-blooded animals. We have had the opportunity of examining.

3. *Of the Abductor Nerve, or the Sixth Pair.*

The single trunk, or the two branches which compose this nerve within the cranium, penetrate the dura-mater above the point of the os petrosum. They advance a short way between its lamina, and reach the cavernous sinus, where they are united, and bathed in the blood of the sinus. The nerve then becomes somewhat thicker; it receives or gives a number of filaments, which communicate with the great intercostal nerve. It afterwards proceeds into the orbit by the superior fissure, and terminates in the substance of the abductor oculi.

We have observed that the same disposition prevails in other red-blooded animals.

ARTICLE IV.

Of the Tri-facial Nerves, or the Fifth Pair.

WE have pointed out the manner in which the nerve of the fifth pair separates in vertebral animals;

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animals; we shall now follow each of its branches, in the different classes, commencing with the *ophthalmic* branch, or that which proceeds to the eye.

I. *Of the Nervus Ophthalmicus, or First Branch of the Fifth Pair in Man, and other Mammiferous Animals.*

A. *In Man.*

The first branch of the fifth pair comes out of the cranium, by the sphenoid-orbital fissure, with the third, fourth, and sixth pairs. It frequently detaches a very remarkable transverse branch to the fourth pair. Before it reaches the interior of the orbit, and while it is still covered by the dura-mater, it divides into three branches: one is directed towards the nasal edge of the orbit; the second towards the arch or frontal edge; and the third towards the temporal edge. The second is the thickest of the three.

The *nasal* branch is inferior and internal; it divides into two smaller ramifications.

One of these branches proceeds towards the optic nerve, unites with the small branch of the third pair, which is sent to the lesser oblique muscle, and by this union produces a nervous enlargement, called the *lenticular* or *ophthalmic* ganglion. This ganglion usually sends off the ciliary nerves disposed in two bundles. They
are

are each composed of several filaments, which enter the globe of the eye obliquely, where we shall have occasion to examine them when we treat of that organ.

The other branch, called the *ethmoidal*, also frequently furnishes one or two small twigs, which unite to the bundle of the ciliary nerves. It proceeds along the nasal edge of the orbit, and divides near the anterior internal orbital hole; one of the filaments enters that hole, follows the canal of which it is the aperture, re-enters the cranium below the dura-mater, comes out again towards the anterior edge of the cribriform lamella, penetrates the nasal membrane, and is lost above the superior spongy bones, and on the sides of the vertical lamina. The second filament proceeds towards the pulley of the obliquus major, and divides into a great number of fibres, some of which are distributed to the skin of the forehead, near the nasal angle of the orbit; others to the orbicularis palpebrarum; some to the frontal muscle, the caruncle, and the membranes of the lachrymal canal. Some of these fibrillæ usually unite to others which come from the facial and sub-orbital nerves.

The second branch of the ophthalmic is called the *frontal*. It is situated between the periosteum of the roof of the orbit, and the elevator of the superior eye-lid. It is separated almost from its origin into two branches; one, which is the

most internal, is directed towards the obliquus major oculi, and unites with some filaments produced by the second branch of the division of the ethmoidal branch; the other, which is more external, proceeds to the outside of the orbit by the supra-orbital hole or notch, and expands on the forehead, giving filaments to the skin, the adjoining muscles, and the periosteum.

Lastly, the third branch of the ophthalmic nerve is called the *lachrymal*. It is situated towards the temporal or external edge of the orbit, and proceeds towards the lachrymal gland. Before it reaches that gland, it is divided into several filaments; one passes through the gland, and is lost in the tunica conjunctiva: another is distributed almost entirely in the gland; a third, and sometimes a fourth, after also going through the gland, divides into seven or eight filaments, several of which pass into the temporal fossa by the sphenomaxillary fissure, and join with other filaments from the deep seated temporal nerve; one of these pierces the os-jugale, and unites on the cheek with branches of the facial nerve.

B. In other Mammiferous Animals.

The ophthalmic branch in Mammalia reaches the orbit by the sphenoorbital fissure, or rather foramen, which is also the optic foramen. It is separated into two other branches within the
cranium,

cranium, and passes in the substance of the dura mater, with the third, fourth, and sixth pairs. Upon reaching the interior of the orbit, it divides, as in man, into three branches.

That of the internal part of the orbit, which corresponds to the *nasal*, is the largest of the three. It is divided into five or six small branches. Some penetrate the frontal sinuses, by small holes in the vault of the orbit, which are very apparent in the *sheep*, others which are considerably larger enter the nasal cavity by the internal orbital foramen. Inclosed in an osseous canal, they ascend into the cranium through the large holes in the os cribriforme, which we have already noticed, and then go out again by the ethmoidal foramina, to be distributed to the nasal membrane. They may be easily followed in the Ruminantia. One or two others go to the levator palpebræ superioris muscle. One of these twigs assists in forming the *lenticular ganglion*. In the *dog*, two ciliary nerves arise from this ganglion, which are afterwards divided: three or four filaments rise from it in the *calf*. Finally, one or several of these filaments terminate in the obliquus inferior, and in the glandula Harderi, of which we shall speak in treating of the Organ of Vision, and the tears. These nerves are particularly remarkable in the Ruminantia.

The middle branch of the ophthalmic nerve is superior. It is situated under the osseous roof of

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the orbit, and is divided into two principal ramifications ; one, which is external, furnishes two filaments, that are lost in the rectus superior oculi and elevator of the eye-brow, anastomosing, at the same time, with other filaments. The internal ramification transmits branches to the musculus rectus internus, and one which is very remarkable, and frequently a very thick twig, passing through the superciliary notch or foramen, spreads under the skin of the forehead, where it is lost in the muscles.

The third branch of the ophthalmic nerve is composed of a great number of filaments, which, though close to each other, are very distinct. They are almost all lost in the lachrymal gland.

II. *Of the Nervus Maxillaris Superior, or Second Branch of the Fifth Pair in Man and other Mammiferous Animals.*

A. *In Man.*

Having passed out of the cranium through the round foramen of the os sphenoides, this nerve almost immediately furnishes a small branch, which enters the orbit by the inferior fissure of that fossa. This branch unites with another belonging to the lachrymal nerve, with which it passes, as we have already shewn, into a small canal of the os jugale, to be distributed on

the cheek, anastomosing at the same time with the facial and sub-orbital nerves, and sometimes behind with the temporal filaments of the inferior maxillary.

The maxillaris superior having reached the interval between the base of the pterygoid processes, and the superior part of the malar tuberosity, sends off one or two branches, which in the latter case almost immediately re-unite, and form a ganglion or enlargement, which is situated before the sphenopalatine foramen. Several filaments proceed from this ganglion in different directions, and form very remarkable nerves: they are subject to variation in their number, but seldom in their distribution.

Four or five filaments proceed, in the first place, from the internal side: these enter the nostrils by the sphenopalatine foramen, and are distributed to the olfactory membrane.

We next observe behind the ganglion, another small filament, which entering the canal at the base of the pterygoid process, proceeds posteriorly to the point of the os petrosum. This has been named the *Vidian* nerve, from the author who first described its course. On leaving this canal, the nerve forms two branches; one of these branches returns into the cranium, passes through a small hole of the os petrosum, which joins the canal of the portio dura, and in which it is united to the facial nerve. The other branch of the vidian nerve enters the canal of

the carotid artery, and is united to the filaments of the fifth pair, which join the sympatheticus major. Sometimes this branch accompanies the carotid artery, and only unites with the great sympathetic nerve in the superior cervical ganglion.

Lastly, the largest branch, which appears to be the continuation of the trunk, arises from the inferior part of the ganglion; a great part of it enters the pterygo-palatine canal, and it is there divided into several filaments, which pass through the bone: some are distributed in the olfactory membrane, and others lose themselves posteriorly in the uvula and the small muscles. The trunk comes out by the posterior palatine foramen, and proceeding forward, is divided into two or three branches on the arch of the palate.

Having detached the two branches which produce the sphenopalatine ganglion, the maxillary nerve proceeds towards the aperture of the sub-orbital canal; but before it enters that canal, it furnishes a small branch, called the *alveolar*, which is frequently divided into two others; one enters the maxillary sinus, another proceeds to the alveoli, into which it penetrates. It furnishes also a number of filaments to the gums and muscles of the lips.

Having passed into the sub-orbital canal, this nerve takes the name of *sub-orbital*: it detaches a considerable branch, which proceeds in the
substance

substance of the bone, penetrates the sinus, and is distributed to the roots of the teeth. The trunk issues from the bone through the sub-orbital foramen, and having reached the cheek, all its filaments are lost in the muscles of the face, a great number of them uniting with the ramifications of the facial nerve.

B. In other Mammiferous Animals.

We have already observed, that the maxillary nerves come out of the cranium, in the greater number of these animals, by the hole situated in the middle fossa, before the spine of the os petrosus.

The single trunk, when it arrives on the outside of the cranium, becomes considerably enlarged, and its fibres seem to cross each other in such a manner, that the two branches which it soon after forms, appear to be produced by opposite filaments, viz. the posterior, or sub-maxillary branch, by the anterior filaments, and the anterior, or supra-maxillary branch, by the posterior fibres. This disposition is very remarkable in *dogs*, but is less conspicuous in the *Ruminantia*.

The supra-maxillary nerve proceeds almost horizontally from behind, forward. Having reached the anterior and inferior parts of the temporal fossa, it divides into a great number of fasciculi. One bundle, which consists of

four or five considerable filaments, proceeds towards the sphenopalatine foramen: this fasciculus then divides into two; one branch is sent into the cavity of the nostrils, and furnishes a considerable ramification, which is spread out upon the fleshy substance of the palate. Sometimes, as in the Ruminantia, this branch separates from the trunk, even before it enters the sphenopalatine hole.

The other branch of the maxillaris superior, which enters by the sphenopalatine foramen, passes into the body of the os maxillare superius, detaches ramifications to all the teeth, and goes out by the sub-orbital foramen; it then expands in the form of a goose's foot over the face, and anastomoses with the facial nerve.

But besides these two principal branches produced by the superior maxillary nerve, there are some other very remarkable filaments, which are detached almost immediately after it leaves the cranium.

The first is a very small twig, which, after anastomosing with a ganglion, of which we shall speak hereafter, is sent into the body of the temporal muscle, through which it passes, affording it, at the same time, a number of filaments; it afterwards perforates the inferior part of the orbit, and penetrates into the nose.

Another, and far more remarkable filament, arises from the sphenopalatine branch; it forms a ganglion, which is joined by several twigs,
and

and among others, by that which we have just described. A flat nerve afterwards separates from this ganglion, which, though much larger, appears to be the continuation of the filament at present under consideration: it passes into the body of the bones, between the palatine and the convexity of the pterygoid process: it furnishes several filaments, one of which is very distinct, and descends to the floor of the nostrils.

Such is the general distribution of the supermaxillary nerve in most mammiferous animals. This succinct description, taken from the *dog*, the *rabbit*, the *sheep*, and the *calf*, proves that the distribution does not differ from that which takes place in man, except in circumstances necessarily resulting from the conformation of the bones of the face,

III. *Of the Nervus Maxillaris Inferior, or Third Branch of the Fifth Pair, in Man, and other Mammiferous Animals.*

A. *In Man,*

This is the largest of the three branches furnished by the tri-facial nerve; it comes out of the cranium, as we have already observed, by the oval foramen of the os sphenoides. It appears, at the base of the cranium, on the edge which separates the temporal from the guttural fossa, on the inner side of the external ptery-

goid muscle; it is almost immediately divided into two principal trunks, one superior, the other inferior. The first is subdivided into five branches, and the second into three. Thus there are eight divisions of this nerve.

1. The first branch detaches some filaments to the articulation of the jaw, and to the temporal muscle; then, proceeding upward to the notch between the two processes, it penetrates into the heart of the masseter muscle, through which it is distributed.

2. and 3. The second branch of the first trunk passes into the posterior and lower part of the temporal muscle. The third also proceeds in the same direction, but a little more anteriorly; it frequently anastomoses with a filament of the lachrymal nerve, as we have already observed.

4. The fourth branch passes between the two pterygoid muscles, to which it detaches some small filaments; it then proceeds to the outside of the buccinator muscle, where it divides into a great number of filaments, some of which are distributed to that muscle, and the muscles of the lips in general, while others unite with the facial nerve.

5. The fifth branch is one of the smallest; it is sent into the internal pterygoid muscle, and those of the velum palati.

6. The sixth branch appears to be the trunk of the nerve itself; it therefore retains the name of *maxillaris inferior*; it passes between the two pterygoid

pterygoid muscles, and is directed towards the dental canal of the lower jaw; but before it enters it, some filaments are detached to the mylo-hyoideus and digastricus, and to the sub-maxillary glands. In passing along the canal, it distributes branches to each of the teeth, and issuing from the jaw through the foramen mentale, is lost amongst the muscles of the lower lip, anastomosing occasionally with filaments of the facial nerve.

7. The seventh branch is destined for the tongue; it advances, with the preceding, between the pterygoid muscles; it there receives a small filament, which is derived from the facial nerve, and which has been named *chorda tympani*: it proceeds towards the tongue, and when arrived at the origin of the stilo-glossus muscle, above the maxillary gland, it produces some fibres, which are frequently united, and form a small ganglion, from which some filaments that penetrate that gland are detached. The nerve afterwards passes between the hyoglossus and the gland situated below the tongue. It penetrates the body of that organ, and is distributed in its substance, in the muscles which sustain it, and in the skin which covers it.

8. Lastly, the eighth branch is the most posterior; it frequently arises from two roots, between which a small artery is transmitted. The single trunk passes behind the condyle of the jaw, before the meatus auditorius: it is subdivided

vided into a number of small filaments, many of which unite with the facial nerve on the external part of the temporal muscle. On this account it has been called the *superficial temporal nerve*.

B. *In other Mammiferous Animals.*

We have shewn the disposition of this branch in the Mammalia, until its exit from the cranium by the foramen ovale. It furnishes, almost immediately after its separation, a pretty large branch, which is directed into the parotid and maxillary glands; it afterwards divides into two other branches, one internal, which loses itself by several small filaments in the body of the muscles, and even in the substance of the tongue; the other, which is external, affords a number of ramifications to the pterygoid muscles, and to those of the cheeks and lips, which they traverse in their progress towards the skin of the face, where they unite with the filaments of the sub-orbital and facial nerves. The largest filament, or the continuation of the branch itself, passes into the dental canal; it there supplies the teeth, and issuing from the foramen mentale, terminates in the muscles of the lip, in the form of a goose's foot. The other small filaments are distributed nearly as in man.

In the *calf* the inferior maxillary nerve divides into four principal portions, soon after it
leaves

leaves the cranium. The most posterior, which is the third, with respect to thickness, proceeds backward, and below the condyle of the jaw, where it forms two branches: one is slender, and penetrates the parotid gland, where it divides into a number of small filaments, which unite with those of the facial nerve; the other branch follows the circuit of the jaw, and advances to the front of the mouth; it unites, as it passes along the cheek, with the middle branch of the facial nerve, from which it previously receives several anastomosing filaments.

The next branch of the maxillaris inferior is the most slender of the four; it is very long, follows the ramus of the jaw, and is lost in the buccinator muscles and buccinal glands.

The third branch passes into the dental canal, and is there distributed, in mammiferous animals in general, as we have already pointed out.

Finally, the fourth is the lingual branch; this is the thickest and the most anterior; it is flat, in the form of a broad ribbon. It terminates like a fan in radii, which run into the muscles of the tongue, and the parietes of the mouth.

IV. *Of the Nerve of the Fifth Pair in Birds.*

The fifth pair presents nearly the same distribution in birds, as in Mammalia.

The ophthalmic nerve comes out of the cranium

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nium by a particular foramen of the orbit on the outside of the optic nerve. It proceeds some way in the substance of the bone before it reaches its surface. It is thick, and describes a curvature which follows that of the arch of the orbit. Its division does not commence until it is beyond the fossa; it usually penetrates into the body of the bones of the face above the nasal sinuses. It divides into three branches, the superior, which is the smallest, is lost in the pituitary membrane. The second branch, which is the thickest of the three and the longest, is received into an osseous canal, passes above the nares, and terminates at the extremity of the bill by a great number of filaments. The third branch appears to be entirely lost in the skin which surrounds the aperture of the nostrils.

The superior maxillary nerve comes out by the same hole with the inferior, precisely above the os quadratum. It proceeds from behind forward to the inferior part of the orbit. Two filaments are detached from it in its progress; one unites with the ramifications of the ophthalmic nerve; the other ascends towards the internal side into the body of the pterygoid muscles. It penetrates the maxillary bones, and loses itself on the lateral parts of the bill. Its distribution is very remarkable in *ducks*. Each of the denticulations with which their bill is furnished, appears to receive four or five filaments.

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The inferior maxillary nerve separates from the superior, and is directed obliquely downward. It detaches at first some branches to the pterygoid muscles, and to the quadratus, which we shall describe when we treat of mastication: The trunk afterwards descends outwardly, and when arrived at the inferior jaw, it divides into two branches, one internal and one external. The internal, which is the continuation of the trunk, penetrates the maxillary canal, and proceeds, in that manner, to the anterior extremity of the mandible. In birds that have denticulations, as ducks, each process receives filaments from this nerve. The external branch separates from the preceding, passes through the bone of the mandible, and spreads upon its outside, under the skin or horny substance which covers the bill to its extremity.

V. *Of the Nerve of the fifth Pair in Reptiles.*

Reptiles have the three branches of the fifth pair. In the *sea tortoises* the ophthalmic passes, some way, in the dura mater before it enters the orbit. It transmits filaments to the muscles of the globe of the eye, and particularly to the two lachrymal glands. The superior maxillary branch is the largest of the three. It is united to the inferior branch at its origin, but when it reaches the interior of the orbit, it separates from it to take another direction. It passes along the
floor

floor of the orbit, describing a very marked curvature, the convexity of which is external. A very great number of filaments proceed from the concave or internal side, which are lost in the lachrymal gland. The trunk is afterwards divided into two branches:—one internal, which corresponds to the spheno-palatine and sub-orbital nerve. It furnishes filaments to the palate and to the nerves; and when arrived at the anterior part of the orbit, it proceeds outwardly and spreads upon the face. The other branch of the principal trunk is external; it passes also upon the floor of the orbit, to which it gives many filaments, and at length issuing from the inferior part of the orbit, it expands upon the face, anastomosing with the other facial nerves.

The inferior maxillary branch proceeds almost vertically downward to the posterior part of the orbit, before the petrous and articular process of the os temporum. In its course towards the lower jaw, it passes between the temporal and pterygoid muscles, to which it sends several filaments. Having arrived at the lower jaw, before the articular surface, it enters the oblong aperture, and divides in the substance of the bone. It forms several branches on the inner part of the jaw, which are lost in the muscles of the tongue, and on the outside some others which ramify under the skin.

VI. *Of the Nerve of the Fifth Pair in Fishes.*

We also find in fishes the three branches of the fifth pair, which we observe in man.

The ophthalmic or most superior branch arises in the cranium, and proceeds obliquely outward and forward towards the posterior part of the orbit, into which it penetrates. Arrived there, it presents some variations in different species with respect to its sub-division. It usually furnishes three principal branches as in the *carp*, the *salmon*, the *cod*, and probably in the other spinous fishes; but in the *ray*, and in the *saw-shark* (*squalus pristis*) this division takes place at a greater distance, and beyond the orbit, as we shall see in describing these branches.

The first branch is the smallest and the most internal. It terminates at the margin of the cavity of the nares. In the *ray* the branch passes out of the orbit without dividing, soon after it detaches two filaments: one, which is thick, crosses above the nares, to which it detaches several filaments, and passes on to lose itself in the lateral parts of the snout. In the *saw-shark*, the part of the ophthalmic branch which proceeds to the nares, is not remarkable. It consists of single filaments which are detached from the branch we are about to examine.

The second branch of the ophthalmic nerve of the internal side in spinous fishes, is the most
con-

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considerable of the three. It divides into two branches, one of which ramifies in the fleshy parts of the upper lip, where its filaments unite with those of the maxillaris superior. The other is distributed in the soft parts adjacent to the angle of the mouth. This, at least, is the disposition in the *salmon*, and the *carp*. In *rays* the continuation of the trunk supplies the place of this branch. It is directed forward towards the extremity of the snout where it terminates. In the *saw-fisk*, the branch we are now tracing proceeds above the muscles of the ball of the eye, and is sent forward into a groove formed above the snout. It there divides at the external side into an infinite number of filaments, in the form of network, the ramifications of which appear to proceed to the teeth or hooks with which the snout of this fish is armed.

The third branch of the ophthalmicus proceeds to the lateral parts of the face, and is distributed to the muscles of the jaws in spinous fishes. This branch does not exist in the *ray*, but in the *saw-fisk* it is very distinct, and very large. It passes through the orbit below the two superior muscles of the eye, furnishing some filaments which extend to the bulb. It is then directed forward, and confounded with the preceding branch.

We ought not to omit noticing here one very remarkable peculiarity, to which we shall, however, return in the article on Secretion. The two branches of the ophthalmic nerve appear to

change their nature at the place where they reunite. They assume a black colour, and particular consistency. We have had occasion to make the same observation on this black colour of the nerve in the *tope*, (*Squalus galeus*), in which it is still more conspicuous, and in which its distribution is highly important. In this species all the advanced part of the head, before the mouth, is perforated with numerous pores, through which a gelatinous humour exudes, on the slightest compression. When the skin is removed, we observe that this humour is contained in certain cells, formed by a very compact white fibrous substance. A great number of the extremities of the nerves are distributed to the parietes of these cells. We shall return hereafter to the presumed uses of this liquor. It is sufficient at present to notice its existence.

The second branch of the fifth pair of nerves, which represents the maxillaris superior, is intermediate. It passes below the optic nerve, towards the middle and inferior part of the cranium. Having arrived below the nares, it divides into two, three, or several branches, some of which proceed towards the angle of the mouth, and terminate in the cirri, when these appendages exist; others proceed towards the middle part, where they are distributed into the substance of the lips. This, at least, is the case

in the spinous fishes we have had the opportunity of examining.

The *saw-shark* and the *ray* exhibit different appearances. In the first of these fishes, the maxillaris superior is divided, almost immediately after it leaves the cranium below the orbit, into three principal branches. The first, which is directed forward, and is very thick, passes below the muscles of the eye, to which it transmits some filaments. It in particular detaches one which proceeds into the globe of the eye; it then passes to the inferior surface of the root of the snout, sends some filaments to the margin of the nares, and afterwards penetrates into the longitudinal canal of the muzzle, which receives the ophthalmicus. The middle branch consists of several filaments, which are distributed to the muscles of the mouth, and principally towards its angle, where they are lost in the skin which forms the lips. In the *thornback* (*raja clavata*) the disposition is nearly the same, but we observe that the filaments which in the *saw-shark* appear to terminate in the hooks of the snout, terminate in the tubercles or spines, with which the different species of rays are armed.

The third branch of the fifth pair, or maxillaris inferior, presents no peculiarity. In the osseous fishes, when it arrives towards the angle of the jaw, it is lost in the bones which form it
by

by very fine filaments; the number of which varies. In the chondropterygii, this nerve is directed much more backward, and is distributed among the muscles of the lower jaw.

ARTICLE V.

Of the Facial Nerve, or Sympatheticus Minor of Winslow.

A. In Man.

WE have explained the origin of this nerve, and shewn that it is almost always distinct from the portio mollis. Having entered the meatus auditorius internus, it passes into the canal named the *aquæduct* of *Fallopian*.

It follows the different curvatures of that canal, and receives in it the filament of the vidian nerve, which we pointed out in treating of the sphenopalatine ganglion of the supra-maxillary branch. It afterwards furnishes, in the cavity of the tympanum, two small twigs to the ossicula auditus; and another more considerable one, some lines before it passes out, through the stylo-mastoid foramen. This filament enters a small osseous canal, which conducts it into the cavity of the tympanum. It passes under the incus on the tendon of the internal muscle of the

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malleus. It goes out by a small hole in the base of the tympanum to communicate with the lingual portion of the third branch of the tri-facial nerve, or fifth pair, to which it unites by a very acute angle.

Having left the base of the cranium, the facial nerve divides into several branches, which vary in number, but which frequently amount to fourteen or fifteen.

The most posterior is called the *occipital*. It proceeds behind the mastoid process, unites to a superior cervical pair, and is afterwards divided into two smaller branches, one of which is lost on the concha of the ear, and the other in the skin, and superior part of the muscles of the neck.

The second branch communicates by one or two filaments with the superior part of the cervical ganglion of the sympatheticus major. It terminates in the muscles which arise from the styloid process, and on that account has been named the *stylo-hyoidean* branch.

The third branch is sent to the digastric muscle.

The trunk of the facial nerve passes afterwards into the parotid gland, which it crosses, and to which it affords a great number of filaments.

The fourth branch produced by the facial nerve is distributed to the anterior part of the concha of the ear, and to the aponeurosis of the temporal muscle.

The

The fifth and sixth branches are disposed of nearly in the same manner, and form with each other very numerous anastomoses. They are called the *temporal* or *jugal* nerves.

The seventh branch very much resembles the preceding. It unites with them and with the adjacent branches, and proceeds to the orbicularis palpebrarum muscle, where it terminates in a kind of plexus.

The eighth branch is divided almost immediately after its origin into three others, which also extend to the orbicularis, but terminate in its inferior part.

The ninth branch passes between the duct of the parotid gland and the zygomatic and masseter muscles. It proceeds towards the internal angle of the eye, forming a large plexus on the face, and uniting with a great number of filaments of the sub-orbital nerve.

The tenth, eleventh, twelfth, and thirteenth branches also go to the face, one under the other. They furnish filaments to all the muscles, and form a real nervous net under the skin.

The fourteenth branch follows the edge of the lower jaw. It is lost in the muscles of the lower lip, and unites with the nervous plexus of the face.

Lastly, a number of filaments come from the parotid gland, which have arisen from the division of the facial nerve. Some unite with the

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branches we have described ; others are lost in the musculus cutaneus, and in the skin.

It follows from this description of the facial nerve, that it covers the whole of the face, the temples, the ears, and a portion of the occiput and neck, and that it communicates with a great number of other nerves ; this induced Winslow to name it *sympatheticus minor*.

B. In other Mammiferous Animals.

We find almost all these branches in the other Mammalia ; the variations depend entirely on the different forms of the parts to which they are distributed, and the extent of the muscles. In animals, for example, that have the concha of the ear very long, the branch which unites with the first cervical pair is much larger, and may be more easily traced on the surface of the cartilages, where it accompanies the blood-vessels. In the same manner, we find that the branches which proceed to the temporal muscle, are very large in the Sarcophaga. It may in general be remarked, that the facial plexus is more complicated.

As we have particularly examined this nerve in the *calf*, it will not be improper in this place to present a succinct description of it.

It leaves the cranium by the fissure at the base of the mastoid process ; it crosses the parotid gland, to the substance of which it transmits

mits a number of filaments, It in particular detaches one very remarkable branch, which, as we have already shewn, unites with another from the maxillaris inferior. Upon leaving the parotid gland, the facial nerve divides into four branches; two ascend before the ear, and proceed to the superior lateral and posterior parts of the face; the other two branches are sent to its anterior parts. The most inferior of these branches divides, sub-divides, and anastomoses in every direction with the filaments of the nerve of the chin. The superior receives a large branch from the maxillaris inferior, which passes behind the condyle of the jaw; thus united in a single trunk, they form an expansion like a goose's foot, which anastomoses with the sub-orbital nerve.

This facial nerve presents a very remarkable peculiarity at its origin: it has two roots; one is the portio dura of the auditory nerve, which enters the internal meatus, from which it escapes by the fissura Glaseri, or foramen stylo-mastoidium, which are in this animal the same aperture; the second root appears to proceed from a considerable ganglion of the posterior part of the par vagum. This ganglion is situated in a particular depression of the inferior surface of the bone of the tympanum: it also appears to unite with the sympatheticus major, which assumes almost a cartilaginous consistence. Two or three short filaments concur in the formation

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of this root ; it afterwards becomes thicker, and penetrates into the fissure, where it meets the other root of the facial nerve ; it transmits a filament to that root, and continues to proceed outward, before and below the ear.

In *rabbits* the facial nerve comes out of the cranium immediately under the cartilage of the ear, and the meatus auditorius externus, from which it is separated by only a small boney ridge.

C. In Birds and Reptiles.

The facial nerve exists in birds and reptiles, but its size is small, because these animals have no lips, and because their mouth, as well as a great part of their face, is covered with a horny or scaly substance, in consequence of which these parts have but little motion or sensibility. We find, however, some of the branches : they are not indeed easily followed in dissection, but their trunk always exists.

D. In Fishes.

The facial nerve is very considerable in cartilaginous fishes ; it is detached from the brain by a single trunk, very distinct from the auditory nerve, which belongs also to the fifth pair ; but soon after, and even in the cavity of the cranium, it separates into two branches, one ascends the cranium, and passes out through a particular

particular hole, and is distributed under the skin; the other, which is thicker, proceeds horizontally towards the cavity of the ear, which it enters also by a particular foramen. Arrived in that cavity, it proceeds under the vesicle which contains the amylaceous or calcareous matter of the ear, where it unites with the auditory portion of the fifth pair: the common trunk afterwards penetrates the cavity of the ear, to proceed outwardly, and to be distributed in a great number of ramifications to the soft parts which envelope the head.

ARTICLE VI.

Of the Auditory Nerve, or Portio Mollis of the Seventh Pair.

IN the Article on the Origin of the Nerves in the different classes of animals, we have pointed out the manner in which the auditory nerve arises from the brain. As it is very short, and as it passes into the organ almost immediately after its origin, we have at present only to describe, in the cerebral cavity, its connections with the facial nerve, or portio dura.

In Man, and the other Mammalia, it proceeds, with the facial nerve, into the cavity of the os temporum, which forms the meatus auditorius

ditorius internus, and enters into the labyrinth by several holes, the number and the magnitude of which vary in different animals. In the Article on the Ear, we shall point out its farther distribution in that organ; it is very soft, and we do not discover fibres in it, as in all the other nerves, the olfactory excepted.

In birds, the two nerves have nearly the same connection. The auditory is very large, soft and reddish; it is received into a deep conduit, on the internal surface of the cranium, whence it penetrates into the labyrinth by several small foramina.

In reptiles, it is nearly the same as in birds.

But in fishes, the auditory nerve is very much separated from the facial; it even approaches so near to the origin of the fifth pair, that it may be regarded as a branch of it. In the cartilaginous fishes, as the *rays*, it passes into the cavity of the ear, by a particular foramen, and not by a number of holes, as in the other classes. In the spinous fishes, as the ear is free, and even situated in the same cavity with the brain, the nerve is distributed directly into that organ.

ARTICLE VII.

*Of the Pneumo-gastric Nerve, or Par Vagum,
vulgarly called the Eighth Pair.*

A. *In Man.*

THE numerous filaments which compose this nerve, at its origin from the brain, approximate and form a kind of compressed cylinder; they then pass out of the cavity of the cranium by an oblong aperture of the dura-mater, situated below the posterior foramen lacerum.

Another nerve, which ascends from the canal of the spine, where it arises by several filaments from the spinal marrow, comes out through the same hole, on which account it is named the *accessorius* of the eighth pair.

Having reached the base of the cranium, these nerves seem to receive a different destination. The par vagum, properly so called, is transmitted to the lungs and the stomach. The *accessorius* is directed towards the shoulder.

The principal trunk communicates, in the first place, with the hypoglossal, the great sympathetic, the superior cervical, and the glossopharyngeal nerves.

It afterwards descends almost vertically on the fore part of the neck, to the breast, and is placed
near

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near the carotid artery, and great sympathetic nerve; but in its course, it furnishes the neighbouring parts with a number of branches, which we shall notice.

One is intended for the larynx, and is distributed to the muscles and glands of that part; another is detached towards the middle of the neck, and, forming an arch internally, it ascends towards the great hypoglossus. Several filaments are given off from the convexity of this arch, and descend into the breast; they then proceed to the pericardium, and are ramified in its substance, forming the plexus called the *superior cardiac*.

When arrived near the clavicles, the par vagum of the left side sends forward some filaments which unite with the plexus we have just mentioned. The analogous filaments on the other side are produced by the recurrent nerve; after this, the trunk proceeds inwardly, and passes into the thorax, between the veins and the arteries: it presently divides into two large branches; the most external is the continuation of the trunk; the internal is called *nervus recurrens*, because it re-ascends, and partly returns again out of the thorax.

This recurring branch turns round the arch of the aorta on the left side, and the sub-clavian artery on the right.

The left recurrent nerve detaches some branches, which, uniting with some others, produced by

ART. VII. PNEUMO-GASTRIC NERVE. 237

by the great sympathetic, form a *pulmonary* plexus round the pulmonary artery and the aorta, and having entered the pericardium, where they form the *inferior cardiac plexus*, they are distributed to the heart. The recurrent branches having arrived near the trachea arteria, divide into filaments, some of which ascend to the larynx, and are distributed to the small muscles of that organ, under the name of the *laryngeal nerves*.

The trunk of the pneumo-gastric, after furnishing the recurrent branches, passes behind the pulmonary vessels, and detaches a number of filaments which surround the bronchia, and produce a plexus, denominated the *pulmonary*: this plexus receives a filament from the great sympathetic nerve.

The branches of the par vagum afterwards continue to descend in the thorax, along the œsophagus, to which they afford a number of filaments; one nerve of the pair passing before the œsophagus, the other behind: in this manner they both arrive in the abdomen, where they form a considerable plexus under the envelope of the stomach, produced by the peritonæum: they also furnish some filaments to the hepatic, splenic, and solar plexuses, as we shall shew when we treat of the great sympathetic nerve.

The trunk of the accessorius separates from the par vagum, as it leaves the cranium; it is directed a little backward, as it descends along
7 the

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the neck ; it passes along the superior portion of the sterno-mastoid muscle, to which it gives some branches. It afterwards proceeds to the trapezius muscle, in which it terminates, after detaching some filaments to the two splenii, between which it passes.

B. *In other Mammiferous Animals.*

This distribution of the par vagum was found nearly similar in four or five species of Mammalia, which we examined for the purpose of tracing it. The *calf* only presented one peculiarity, which we have pointed out in the Article on the Facial Nerve ; but the anastomoses, with the great sympathetic, the recurrent nerves, the cardiac and pulmonary plexus, exhibited no difference, except in the number of the filaments, so far as the accuracy of the Dissector may be relied on. The species we dissected were the *dog*, the *raccoon*, the *hog*, and the *porcupine*.

C. *In Birds and Reptiles.*

We have likewise nothing remarkable to state respecting this nerve in birds and reptiles, though we have made preparations of it in several species. We observe evidently that it is distributed to the lungs, the heart, the œsophagus, and stomach, and that it forms plexuses on these organs, in the same manner as the
great

great sympathetic nerve produces them round all the arteries of the trunk. On leaving the cranium, the par vagum forms decussations with the lingual and *glosso-pharyngeal* nerves; they afterwards separate from each other: the glosso-pharyngeus is posterior, the par vagum in the middle, and the lingual anterior. The par vagum does not always come out of the cranium by a single hole; it is formed of two or three filaments, which afterwards rejoin, upon receiving a communicating filament from the glosso-pharyngeus, and one farther down from the lingual; the nerve then augments somewhat in diameter, and descends into the breast.

D. *In Fishes.*

The par vagum presents a very peculiar disposition in fishes; this difference depends on the nature of the organs of respiration, for which that nerve appears to be specially intended. As the lungs or branchiæ of fishes are situated immediately below the cranium, it is obvious that the course of the nerves must be very short; and as the distribution of the nerve takes place almost immediately after it leaves the cranium, it may be said to have no common trunk.

We shall describe, in a general manner, what is common in the disposition of this nerve, and afterwards point out particularities in different species.

The

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The branches of the pneumo-gastric are distributed to three distinct parts: the first, or anterior, which are the largest, and usually four in number on each side, proceed to the branchiæ; they represent the par vagum of Mammalia: the second, which are much smaller, and two or three on a side, are distributed to the muscles, which move the tongue in the base of the gills, and to the surface of the œsophagus: lastly, the third are single on each side; they form a very thick nerve, which extends along the whole body of the fish, under the *lateral line*.

The *branchial nerves* pass out of the cranium by one common foramen, and separating from each other, proceed towards each of the branchiæ: before they arrive at them, they are divided into two; the posterior branch passes into the gutter which runs along the convexity of the bone that sustains the branchiæ, and, in its course, furnishes a considerable number of small ramifications to the pectinated laminæ of the gills.

The anterior branch is directed into the correspondent gutter in the concavity of the bone, and is there divided in the same manner: the anterior branch of the first ramification re-enters the cranium, and appears to be transmitted to the ear.

The middle branches of the par vagum, which we have distinguished with respect to their distribution, arise sometimes from the
same

same trunk as the last branchial, and afterwards divide into two or three branches; but more commonly they come out of the cranium, as an equal number of distinct branches by one common hole: one of these ramifies upon the muscles that move the branchiæ, and those which act on the teeth of the palate. Another, which is much larger, proceeds along the œsophagus, to which it is distributed; it may be traced to the stomach. The third branch unites with the cervical nerves which proceed to the shoulder, or pectoral fin.

The last branch of the par vagum, and which appears peculiar to fishes, is the long nerve of the lateral line of the body. We have constantly met with it in every one of the fishes we have examined, and its distribution is nearly the same in all. When we trace it to its origin, it is easy to discover that it is the most posterior branch of the nerve, which, instead of descending towards the gullet, proceeds almost horizontally backward and outward, in such a manner as to become almost superficial. It is merely covered by the skin, and retained by a loose cellular substance. This nerve is nearly of an equal thickness throughout the whole of its length, and may therefore be very readily mistaken for a tendon; it does not appear to anastomose with the other nerves, or, if it unites with the inter-vertebral, the filaments are exceedingly slender. When it arrives at the tail,

it terminates by very small radiated filaments, which are distributed to the rays of the fin.

This is the general distribution of the pneumogastric nerve in fishes. The varieties which it presents result from the structure of the species. Thus, in the Chondropterygii, as *rays, sharks, &c.* this nerve is much longer, and all its ramifications proceed from a single trunk, which does not divide until it reaches the part into which it is distributed. In the same fishes, the two longitudinal nerves are situated towards the back, and nearer each other.

The other differences are not sufficiently remarkable to merit a particular description.

ARTICLE VIII.

Of the Glossopharyngeal Nerve.

WE have already described the manner in which the filaments which compose this nerve arise from the brain, and explained the motives which induce modern anatomists to consider them as a distinct pair. We shall now pursue its distribution.

It makes its exit from the cranium, through a hole in the dura-mater, very different from that of the eighth pair. The jugular foramen, into
which

ART. VIII. GLOSSO-PHARYNGEAL NERVE. 243

which the vein of the same nerve passes, separates these two nerves. Still enveloped by the dura-mater, it exhibits a small enlargement, from which two branches are detached: one is directed posteriorly towards the meatus auditorius; another perforates the dura-mater, and unites with the par vagum.

Having reached the base of the cranium, it receives filaments from the facial and pneumogastric nerves; it afterwards divides into several branches—one is partly distributed to the muscles attached to the styloid process, and terminates in the tongue—another unites with the hypoglossus major:—lastly, others are distributed to the muscles of the pharynx, along with some filaments of the great sympathetic nerve, and form a plexus which envelopes the carotid arteries; but the principal destination of this nerve is to the tongue and the pharynx.

Such is the description of this nerve in man. The other mammalia, birds and reptiles, present no remarkable difference. We have not indeed carried our researches, with respect to this particular part, so far in them as in the human body. We have, however, observed, that this nerve proceeds to terminate in the tongue, after having furnished filaments to the muscles which move it. In the *stork*, for example, it comes out of the base of the cranium, by the hole situated below the ear, which corresponds to the posterior foramen lacerum. It leaves this hole

in two filaments, which unite almost immediately, and form a long quadrangular ganglion, from which a small filament is sent inward to the anterior muscles of the neck: the same ganglion detaches a small branch backward, which unites with the eighth pair; and a large branch downward, on the front of the neck: the last is the continuation of the nerve itself; it descends along the œsophagus, and divides into two principal branches; one ascends upon the anterior part of the neck, and is distributed to the muscles of the os hyoides, which include it, in the form of cornua; the other descends on the lateral parietes of the œsophagus, and furnishes a branch to the lingual nerve, with which it anastomoses; the remainder of the nerve continues its course upon the œsophagus. From this description it appears that the distribution of the glosso-pharyngeus is nearly the same as in man.

The nerve which supplies the place of the glosso-pharyngeal in fishes, is plainly that branch of the pneumo-gastric which is detached most anteriorly from the first branchial nerve: it is divided into a great number of filaments, which penetrate the muscles of the tongue, in which they are subdivided. The trunk itself is lost in the inferior part of the throat, before and between the branchiæ.

ARTICLE IX.

Of the Great Hypoglossal Nerve, or Twelfth Pair.

THESE nerves leave the cranium, as we have already shewn, through the anterior condyloid foramen. As soon as they get on the outside of the cranium, they become cylindrical, and form communications with the par vagum, the two first cervical pairs, and especially with the great sympathetic nerve: after this they proceed forward, and a little outward, until they arrive behind the sterno-mastoid muscle. At this place they give off a large branch, which accompanies the jugular vein almost to the middle of the neck, where it forms an arch, and ascends on the anterior part of the neck, and terminates by uniting with some filaments from the first cervical nerves.

Some small branches proceed from the convexity of this arch, and terminate in the muscles.

About two fingers breadth from this first branch, the hypoglossal nerves detach another branch, which is entirely lost in the substance of the thyro-hyoideus muscle.

Finally, the trunks pass between the hypoglossus, and mylo-hyoideus muscles, and receive

ceive some filaments from the lingual branch of the inferior maxillary nerve: they at last lose themselves by minute ramifications in the substance of the muscles of the tongue.

In the other Mammalia this nerve presents the same disposition as in man. In the *calf* it is of a bluish colour, and may at first sight be taken for a vein. It retains this colour until it arrives near and within the ramus of the inferior jaw. It is distributed in the muscles, and even in the substance of the tongue towards its middle part.

In birds, the hypoglossus comes out of the cranium, through the condyloid foramen, behind the par vagum: it is slender at its origin, passes before the par vagum, which it crosses, and with which it partly unites. At this place a small filament is detached from it, which proceeds towards the breast, accompanying the jugular vein.

Continuing its course forward, the trunk of the hypoglossus crosses the glosso-pharyngeus: it then passes under the cornu of the os hyoides, and proceeds towards the superior larynx, where it terminates; but it is previously divided into two branches, the inferior of which is sent forward and downward from the tongue, and the superior upward and inward from the tongue.

We have not observed any nerve analogous to the hypoglossus in fishes.

ARTICLE X.

*Of the Sub-Occipital and Cervical Nerves.*A. *In Man.*

THE trunk formed by the union of the two roots of the *sub-occipital* nerve, pierces the dura-mater below the curvature of the vertebral artery. It runs for a short way in the substance of that membrane, and comes out on the edge of the foramen magnum, behind the condyles: it is then turned towards the notch in the articular process of the first vertebra, where it passes below the vertebral artery. It then forms a ganglion, from which some filaments are distributed to the straight and oblique muscles of the head. The trunk afterwards turns before the transverse process; it communicates by an anterior branch with the *sympatheticus major*, the *par vagum*, and the *hypoglossus*, and by a posterior branch with the first cervical pair: it then proceeds towards the triangular interval of the small muscles of the head, and is distributed to almost all the muscles which are attached to the *os occipitis* by their superior part.

The *first cervical pair* arises in the same manner as the preceding. After passing through the

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notch between the first and second vertebræ, this pair forms a ganglion which sends off two principal branches. The anterior of these communicates with the inferior branch of the sub-occipital nerve, the sympatheticus major, the hypoglossus, and the succeeding cervical pair. The posterior branch, which is more considerable, detaches some filaments which unite with the posterior branch of the sub-occipital, and with that of the next cervical pair. The remainder of the nerve is distributed to the muscles of the back part of the neck. One of the filaments goes forward, communicates with the hypoglossus, and is lost in some of the muscles of the os hyoides, and in the glands of the larynx.

The *second cervical pair* is divided, like all the others, into two branches: the anterior is the largest; it communicates upwards and downwards with the two adjacent cervical pairs, with the sympatheticus and hypoglossus, and lastly, with the branch of the following cervical pair or pairs, which produce the diaphragmatic nerve; after which it divides into several branches.

One branch is sent backward into the muscles of the neck; another forward and obliquely into the lateral parts of the ear, where it communicates with the facial nerve; a third proceeds towards the ascending ramus of the jaw, and is distributed partly into the parotid gland, and partly into the teguments of the ear; a fourth is
lost

lost in the anterior part of the neck, in the musculus cutaneus. All the other branches are united with each other, and with the accessory nerve of the eighth pair. By this union they form a plexus, which produces a great number of filaments to the lateral parts of the neck, some of which communicate with the sympathicus major.

With respect to the posterior division of the trunk of this nerve, it unites with the adjacent cervical nerves, and is lost in the muscles named splenius, complexus, longissimus dorsi, and transversalis colli.

The notch between the third and fourth vertebræ of the neck affords a passage for the *third cervical pair*. It is divided, as the others are, into two branches.

The anterior branch separates into two. The first receives a filament from the preceding pair, and is then distributed to the trapezius muscle, and the sterno-mastoideus. The second forms two filaments; one of which unites with the following pair: it detaches also some others which join the facial nerve, and one very conspicuous branch which constitutes the diaphragmatic nerve. The other filament joins the fourth pair, and partly unites with the great sympathetic.

The posterior branch is distributed to the teguments and muscles of the back of the neck.

The

The *fourth* pair of cervical nerves, on leaving the medullary canal, divides into two branches, in the same manner as all the vertebral nerves. The posterior branch is partly lost in the muscles of the back. The anterior, which is the thickest, communicates with the branch of the preceding pair, which forms the diaphragmatic nerve: it communicates likewise with the great sympathetic, and is divided into three branches; two unite with the succeeding pair, and assist in forming the brachial plexus. The third proceeds towards the shoulder, and is distributed to the muscles of the scapula.

The fifth, the sixth, and the seventh pairs of cervical nerves may be considered generally: they all communicate with the adjacent pairs, and with the great sympathetic. The *fifth* pair transmits filaments to the posterior muscles of the neck, and to those of the anterior part of the thorax: sometimes one of its filaments concurs in the formation of the diaphragmatic nerve; it is, at last, sent into the brachial plexus. The *sixth* is chiefly transmitted by two large trunks to the brachial plexus: the first trunk receives that of the preceding pair, and detaches some filaments to the latissimus dorsi. The second likewise sends a filament to the great pectoral muscle. Finally, the *seventh* pair produces, in the same manner, two large trunks for the brachial plexus, which are united sooner or later

A. X. SUB-OCCIPITAL & CERVICAL NERVES. 251

later to that of the sixth. The inferior branch furnishes two filaments to the subclavian and lesser pectoral muscles.

B. *In other Mammiferous Animals.*

The sub-occipital and cervical nerves exhibit no remarkable differences in any of the Mammalia. They all arise in the same manner as in man. The bulk and extent of the nervous filaments which they produce, depend upon the relative magnitude of the parts to which they are respectively distributed. They all have the same number of nerves, the *three-toed sloth* excepted, which ought to have two pair more; since, as we have shewn in the Third Lecture, that animal has nine cervical vertebræ.

C. *In Birds.*

The number of the cervical nerves varies greatly in this class. The known extremes are ten and twenty-three, equal to the number of the vertebræ. Their disposition is analagous to that observed in man. They are, however, respectively much larger, and undergo many flexures. They are lost, in a great measure, under the skin of the neck, where they may be very easily followed. In general only the last cervical pair contributes to the brachial plexus: the two last pairs seldom concur in its formation.

D. *In Reptiles.*

Tortoises have eight pair of cervical nerves, which are distributed nearly in the same manner as in *Mammalia*. The three last pairs join in forming the brachial plexus. The *green lizard* has four pair of cervical nerves, but only the two last enter into the composition of the plexus. In *salamanders* and *frogs* the cervical nerves cannot be properly distinguished from the dorsal, as these animals have no ribs. A pair comes out between the first and second vertebræ, which is sent to the muscles of the inferior part of the neck, and under the skin that covers them. These nerves also afford some filaments to the shoulder. From this distribution they may be regarded as real cervical nerves. In *frogs* only two pairs enter into the composition of the plexus. In the *salamander* there are distinctly four.

E. *In Fishes.*

As the cervical vertebræ of fishes cannot be positively distinguished from the dorsal, it is very difficult to explain the distribution of their cervical nerves. There are never more than four that merit this name, and frequently there are none to which it can be applied. When these nerves exist, they are distributed to the parts about the throat, or rather to the pectoral fin, over which

which they are spread, as we shall shew when we describe the brachial nerves.

ARTICLE XI.

Of the Diaphragmatic Nerve.

THIS nerve is produced chiefly by the fourth pair of cervical nerves; but it also receives, as we have shewn, a considerable branch from the succeeding pair, and sometimes a slender filament from the sixth; besides, very commonly, a small branch, which is given off from the convex side of the arch, formed on the fore part of the neck by the hypoglossus.

Thus composed, this nerve descends before the neck in a large trunk, to which some filaments from the two last cervical pairs, and the cervical ganglion of the great sympathetic, are united. It detaches some fibrillæ to the scaleni muscles, and the thymus gland, when it exists; after which it proceeds into the thorax, between the subclavian artery and vein. It is involved in the middle reflection of the pleura, passes anterior to the pulmonary vessels and veins in the lateral parts of the pericardium, in order to arrive at the diaphragm.

Here the nerve terminates: it is distributed by radiated fibres in the substance of the muscle.

Some

Some filaments, however, pass to the abdominal surface, and communicate with the subgastric plexus of the great sympathetic nerve.

The diaphragmatic nerve of the other Mammalia is in every respect similar to that of man. It has not always the same origin, but that is also subject to variation in man. It proceeds, however, most commonly, from the fourth cervical and the two following pairs. It also receives the branch from the hypoglossal and great sympathetic nerves. The other circumstances in its distribution do not merit a detail.

We have not been able to discover the diaphragmatic nerve in birds. It is possible, however, that the muscles which are attached to the lungs, and which form so large an aponeurosis, receive some nervous filaments: we must confess, however, that they have escaped our observation.

Reptiles have no diaphragmatic nerve, unless we regard as such the cervical pairs which are lost in the muscles of the neck in those reptiles that want ribs, as *salamanders* and *frogs*. In them these muscles produce the effect of the diaphragm, as will appear in the Article on Respiration.

Fishes having no lungs also want the diaphragmatic nerve. We find, however, some analogy in the probable function, and particularly in the distribution of one of the first vertebral pairs, which is distributed to the muscular

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cular septum that separates the cavity of the branchiæ from that of the abdomen. This nerve is particularly remarkable in the *ray* and the *carp*.

ARTICLE XII.

Of the Dorsal and Lumbar Nerves.

A. *In Man.*

THE *dorsal* nerves leave the canal of the medulla spinalis through the holes which are formed by the corresponding notches of each two contiguous vertebræ.

The first pair comes out between the first and second dorsal vertebræ, and the last between the twelfth vertebra of the back and the first of the loins.

All these nerves divide into two branches upon leaving the intervertebral holes; the posterior, which is the smaller branch, is distributed to the muscles and skin of the back. The anterior branch, which is the larger, communicates by one or two filaments with the great sympathetic nerve, detaches some ramifications to the intercostal muscles, and those of the anterior part of the thorax, and abdomen, and afterwards passes along the intercostal spaces towards the sternum.

The

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The first pair of dorsal nerves is distinguished by its contributing to the formation of the brachial plexus in conjunction with the last cervical pair.

The two following pairs produce some branches which pass through the lateral parts of the breast, and proceed from within outwardly to the teguments of the arm on the internal side.

The twelfth pair is partly distributed to the muscles of the abdomen, and under the teguments; and partly into the muscles called quadratus lumborum longissimus dorsi, and serratus posticus inferior, and to the skin of the buttocks.

The *lumbar* nerves vary in number. They are usually five, sometimes four, and seldom six. They are large in proportion as the vertebra from which they proceed is more inferior. The fifth therefore is usually of the greatest size.

On leaving the intervertebral holes, they divide into two branches, one anterior, the other posterior. The first branch detaches a number of filaments which unite with each of the lumbar ganglia of the great sympathetic nerve, and with each of the preceding and following pairs: it also transmits some branches to the muscles of the abdomen, to the quadratus lumborum, the iliacus, and the skin. The last ramifications are commonly flexuous, in order that they may follow the parts in their extension.

The posterior branch is lost in the muscles of the

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the inferior part of the spine. The number of its ramifications vary considerably.

The *first* lumbar pair furnishes a small branch, which is distributed to the cremaster muscle, and the testicles in men. In women this branch goes partly to the uterus, and partly to the external organs of generation.

The *second* pair also furnishes some filaments which are disposed of in the same manner as those of the preceding: one of them is very remarkable, and sometimes descends to the knee.

The distribution of the *third, fourth, and fifth* pairs is nearly analogous.

The principal branches of each of these nerves unite together, and form three very remarkable trunks, which we shall demonstrate hereafter.

The first is the *anterior femoral* nerve, commonly called the *crural*.

The second is the *sub-pubic* nerve, usually named the *obturator*.

The third, which is produced by a plexus of the lumbar with the anterior sacral nerves, is the *ischiatric*.

B. In other Mammiferous Animals, and in Birds.

In these animals the dorsal and lumbar nerves are exactly similar to those of man. They vary only with respect to their number, an idea of which may be formed by consulting

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the tables of the Vertebræ which we gave in the Third Lecture.

C. *In Reptiles.*

We shall also refer to the tables which indicate the number of the vertebræ in reptiles, in order to shew the number of the nerves which issue from their foramina. The distribution of these nerves is the same as in the other animals, and to point it out would only be repeating what we have already described in man.

D. *In Fishes.*

In this class there is no distinction between the different nerves of the vertebral column. They are all distributed in the intercostal spaces, and present no peculiarity.

ARTICLE XIII.

Of the Pelvic and Caudal Nerves.

THE pelvic or sacral nerves come out of the vertebral canal, by the holes which are commonly called the *sacral*, and which are usually five in number, sometimes more, sometimes less. The posterior branches which come out by the posterior foramina are the least considerable. On
their

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their appearance without the holes they unite with the adjoining branches, and are distributed by a number of filaments to the skin of the buttocks, and to the lateral parts of the anus. The anterior branches are those which produce the sacral or pelvic nerves, properly so called.

The *first* pair proceeds within the pelvis towards the ischiatic notch. Having furnished some filaments to the inferior ganglia of the great sympathetic nerve, it is united and confounded with the succeeding sacral pair. Advancing a little farther, it receives the large trunk formed by the fourth or fifth pairs of the loins: it besides detaches a branch, which separates from the ischiatic portion, while it passes through the notch, and is distributed to the musculus gluteus medius.

The *second* pair gives off some branches which are distributed nearly in the same manner as the first; but it is divided within the pelvis into two portions, the superior of which unites with the trunk of the first pair, as we have already shewn; and the second is confounded with the third pair in order to form the ischiatic nerve. Two filaments are detached from the posterior part of this pair, which accompany it into the notch, but separate from beyond it. The one is lost in the gluteus maximus; the other unites with a branch of the following pair, and forms a small single trunk, which is again disunited, to be distributed to the posterior part of the thigh, and the

leg beneath the skin, and to the teguments of the hip, the anus and the penis, or the vulva.

The *third* pair also unites, as we have stated, to the inferior branch of the second. It is much smaller; at first, it gives some filaments to the great sympathetic nerve, and afterwards furnishes a great number which are distributed within the pelvis on the neck of the bladder in man, and on the lateral parts of the vagina in women. In this place they unite with some filaments from the great sympathetic nerve, and form a very considerable plexus. This pair also furnishes a number of other branches, some of which are sent to the posterior parts of the thigh, and others beneath the skin of the buttocks.

The *fourth* pair of sacral nerves is distributed nearly in the same manner as the preceding. It besides detaches some filaments to the muscles of the anus, and a large branch which unites with others that come from the sciatic nerve, thus forming a very remarkable trunk. This trunk passes between the two sacro-sciatic ligaments, and afterwards divides into two branches; one of which is lost in the muscles of the anus, and the obdurator internus; the other proceeds to the muscles and teguments of the penis in man, and to those of the vulva in females.

Lastly, the *fifth* pair, which is the smallest of the whole, is distributed nearly in the same manner as the fourth.

There

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There are no *caudal* or *coccygeal* nerves in man.

The other Mammalia, and the birds, present no difference worthy of notice in their *pelvic* nerves. There are *caudal* nerves in the Mammalia. They issue from the vertebral canal, by holes which are formed in the vertebræ of the tail. We shall describe them from the *rabbit*.

The *first* pair comes out between the last piece of the os sacrum and the first caudal vertebra. It proceeds from the pelvis before the musculus ischio-coccygeus by the ischiatic notch. It then divides into two branches: one is united to the sciatic nerve; the other continues to advance between the pelvis and the tail until it enters a gland situated under the sixth caudal pair of nerves, where this branch terminates; but, in its course, it unites with a number of nerves, and gives origin to others, thus forming a very remarkable plexus, which we shall name the *caudal*.

The first filament which is detached from this branch, passes under the glutei muscles, to which it is distributed; the branch is afterwards joined on the internal side by a small anastomosing filament, which appears to be derived from the second caudal pair, and on the external side by three or four filaments, which form a reticular plexus, from whence several branches go to the muscles; one which is very considerable, passes into the pelvis, and is lost upon the penis, where it may be easily followed, as its size

continues undiminished: again, the third, fourth, and fifth pair of caudal nerves send filaments to the internal side; after which five or six branches are given off from the external side of the muscles of the penis, and those which arise from the ischium. Finally, the trunk of the first caudal pair is terminated in the gland we have already mentioned.

The sacral and caudal nerves are not distinct in reptiles and fishes. We have pointed out the distribution of those which are sent to the posterior feet, or ventral fins. Those of the tail resemble the intercostals, and are lost in the muscles.

ARTICLE XIV.

Of the Brachial Plexus, and the Nerves of the Thoracic Member.

A. In Man.

WE have described the manner in which the cervical nerves produce the brachial plexus by their union. The nature of this nervous intertexture renders it very difficult to follow each of the four pair of nerves which form it, when they separate to be distributed to the arm.

All these nerves pass into the interval included between the scaleni muscles, and are there

there usually united to the first dorsal pair. When these nerves separate, they form three principal fasciculi, from which all the nerves of the arm arise.

The middle fasciculus produces the *median* and *ulnar* nerves.

The posterior fasciculus detaches the *radial* and the *axillary*.

Lastly, the internal fasciculus gives origin to the *thoracic*, *scapular*, *external* and *internal cutaneous* nerves.

This disposition is, however, so liable to variations, that nothing positive can be established respecting it; but whatever may be the origin of the nerves we have enumerated, their number is constantly found the same. We shall now follow them in their distribution.

1. *Of the Median Nerve.*

This nerve is one of the largest of the arm; at the middle and anterior part of which it is situated on the internal edge of the brachial artery; it descends in this manner, without producing any remarkable branches, as far as the articulation of the fore-arm; it afterwards passes between the tendon of the brachialis internus, and the pronator teres muscles, to which it transmits filaments, as well as to the skin. It produces, at this place, some other very remarkable branches; one is lost in the radialis externus,

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and may even be followed a considerable way in that muscle. The others are sent to the palmaris longus, and to the flexor profundus; but the most constant of all is the branch called *inter-osseous*, which, after receiving an anastomosing branch from the radial nerve, transmits filaments to the flexor longus pollicis, and the profundus muscles; perforates the interosseous ligament, to which it furnishes a filament; reappears on the external surface of the fore-arm, and is lost in the flexor longus pollicis and pronator quadratus.

The trunk of the median nerve accompanies the flexor muscles of the fingers, and reaches the palm of the hand along with the tendons. It detaches several branches to the muscles, the aponeurosis palmaris, and the skin. Lastly, it divides into four or five principal branches near the digital extremity of the metacarpal bones; the first of these branches is lost in the muscles of the thumb; the second divides into two branches, which, after having given off some filaments to the adductor pollicis, run along the edges of the thumb, and at its extremity reunite, forming an arch, from which a considerable number of filaments are detached. The third branch also produces two smaller portions, which are sent in the same manner along the sides of the fore-finger. The fourth is similarly distributed to the middle finger. Sometimes, however, it furnishes only one of the

the lateral filaments, that on the radial side of the finger having been supplied by the third branch. Finally, the fifth branch is distributed on the radial side of the ring finger. The four digital ramifications transmit filaments to the muscoli lumbricales, to the sheath of the tendons, and to the teguments, which it is impossible to trace, although they are exceedingly numerous.

2. *Of the Ulnar Nerve.*

This nerve descends along the internal part of the arm, until it approaches the elbow, where it is received into a particular furrow of the epitrochlea of the humerus. It affords some filaments to the olecranon, and to the muscles inserted in that part. The trunk of the nerve crosses the origin of the flexor ulnaris muscle, and proceeds along the palmar surface of the fore-arm on its ulnar margin. In its course to the wrist it detaches several branches to the articular capsule of the fold of the arm, and to the flexor muscles of the fingers. At the annular ligament of the carpus, or a little before it, the trunk divides into two branches; one is named the *dorsal*, and the other the *palmar*.

The dorsal branch subdivides into filaments, which, after uniting among themselves, and with others from the radial nerve, are lost in the skin of the back of the hand.

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The palmar branch furnishes the two lateral branches of the little finger, and also that which anastomoses with the fifth branch of the median nerve, at the extremity of the ring finger; it likewise sends down some filaments to the lumbricales and interossei muscles.

3. *Of the Radial Nerve.*

The radial is the thickest nerve of the arm. Soon after it separates from the plexus, we find it situated between the ulnar nerve and the axillary artery; it furnishes almost immediately some filaments, which are lost in the skin, and in the triceps brachialis. The trunk of the nerve passes afterwards behind the humerus, round which it turns to re-appear on the external surface between the brachialis externus, supinator longus, and brachialis internus. It also produces, at this place, a sub-cutaneous branch, which accompanies the cephalic vein to the wrist, and several other branches to the radial and supinator muscles. The trunk of the nerve then crosses the supinator brevis, above the articulation of the radius with the humerus, and continues to proceed on the external surface of the fore-arm. It gives a number of branches to the muscles, and then divides into two branches, one of which, having passed under the annular ligament of the convexity of the carpus, is lost in the skin, and the parts which

cover

cover the back of the hand: the next branch, which is the largest, divides into two others before it reaches the annular ligament of the wrist. One produces two ramifications; the first terminates on the dorsal surface of the thumb, and on that of the fore-finger; the second is also distributed to the fore-finger, the middle, and frequently to the ring-finger. The other ramification also proceeds to the convexity of the hand and the fingers, and is distributed nearly in the same manner as the former. It is, however, commonly the smaller of the two.

4. *Of the Axillary Nerve.*

This has also been named the *articular* nerve. It is frequently only a branch of the radial covered by the deltoid muscle under which it passes. It transmits some filaments to that muscle, and to the other muscles near the articulation of the humerus, as the teres-major, the latissimus dorsi, the serratus major, and the subscapularis. One of its branches, which is the most remarkable, is lost in the articular capsule of the humerus.

5. *Of the Thoracic and Scapular Nerves.*

The thoracic nerves in some instances arise separately from the brachial plexus. They are distributed chiefly to the pectoral muscles, and are lost in the mammary glands, and in the skin
of

of the breast. There is frequently a posterior branch which is lost in the substance of the latissimus dorsi, (or *lumbo-humeralis*) muscle.

The scapular nerve passes behind the notch in the coracoid process, and gives branches to the supra-spinatus and infra-spinatus muscles, and to the sub-scapularis.

6. *Of the External Cutaneous, or Musculo-Cutaneous Nerve.*

This nerve perforates the coraco-brachialis muscle. It is afterwards situated between the biceps and the brachialis internus, to both of which it furnishes numerous filaments. Having reached the middle part of the humerus, it divides into two branches; one superficial, and the other deep seated.

The superficial branch is the larger: it descends with the cephalic vein above the tendon of the biceps muscle in front of the fold of the forearm, where it divides into a number of ramifications. Some of these are partly lost in the supinator longus, and in the skin, where they anastomose with other filaments from the radial nerve. Other ramifications descend to the hand, and divide and sub-divide in the skin.

The deep seated branch of the external cutaneous nerve is almost entirely lost in the brachialis internus muscle; one of the filaments penetrates, with the humeral artery, properly so called, into the medullary cavity of the bone.

7. *Of*

7. *Of the Internal Cutaneous Nerve.*

This nerve comes sometimes from the ulnar; it proceeds along the posterior and internal side of the humerus, between the skin and the muscles. When arrived at the fore-arm, it divides into a number of branches which enter the skin, and may be traced as far as the hand.

B. *In other Mammiferous Animals.*

The brachial plexus is produced in the other Mammalia by the three last pair of cervical nerves, and by the first dorsal pair.

The *articular* nerve is exclusively formed by the fifth cervical pair in the *rabbit*, and only one of its filaments enters into the composition of the plexus.

The *thoracic* nerves are detached from the plexus, and are distributed to the muscles of the axilla. We also find a nerve analogous to the *scapular*.

The *internal* and *external cutaneous* nerves are not distinct, but only branches of the three principal cords which represent the *median*, *ulnar*, and *radial* nerves.

At the middle part of the arm the *median* produces a branch which is distributed to the muscles and the skin, and may be regarded as a *musculo-cutaneous* nerve. Having arrived before the bend of the fore-arm, it detaches a number of
of

of filaments which pass deeply along with the tendon of the biceps, and are distributed to the muscles. The trunk continues to accompany the muscles of the palmar surface of the forearm. It divides into two branches, which pass through two particular grooves in the ligaments of the carpus, and are each distributed to the fingers, nearly as in man.

The *ulnar* nerve is the most external and the slenderest of the three. About the middle of the arm it gives off a branch to the extensor muscles of the elbow and to the skin. This branch appears to supply the place of the *external cutaneous* nerve. The trunk of the ulnar having arrived before the articulation of the arm, penetrates the aponeuroses of the muscles which are inserted in the external condyle: it passes along the ulna on the inter-osseous ligament, gives branches to the flexor muscles of the fingers, and terminates in two very long filaments, one of which goes to the external surface of the paw, where it is lost in the skin; the other follows the palmar surface, and is distributed nearly as in man.

The *radial* nerve is also the thickest of the three cords: it winds round the humerus, and furnishes ramifications to the extensor muscles of the forearm: having reached the external part of the arm, it glides between the biceps and triceps muscles, and divides into several branches; one becomes superficial, and proceeds
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to the front of the fore-arm under the skin; the others are lost in the muscles of the anterior part of the fore-arm.

Lastly, the trunk, after supplying the muscles, divides into several filaments, which are lost in the skin on the convex part of the fingers.

C. *In Birds.*

The brachial plexus in birds, is formed exclusively by the last cervical and the two first dorsal pairs. Their intermixture produces only one fasciculus, from which all the nerves of the arm are derived.

The first cords detached from the plexus, are intended for the pectorales major and medius, and the sub-clavius muscles: they are large, and four in number.

A branch, analogous to the *articular* nerve, is afterwards distributed to the muscles which surround the head of the humerus and its articular capsule.

Two large principal cords then arise, which are sent to the wing.

One is directed under the internal or inferior surface of the wing. It first detaches filaments to the biceps and deltoid muscles, then following the internal edge of the biceps, it arrives at the bend of the fore-arm without affording any remarkable branches. Having advanced above the articulation of the fore-arm, immediately

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ately under the skin, it divides into three branches; the external is the most slender, and is partly lost in the radial muscles, and the skin which covers the pollex, or the bastard wing. The middle branch passes deeply under the muscles to which it is distributed; one of its filaments perforates the inter-osseous ligament to get to the superior surface. Lastly, the third or internal branch, proceeds, as the ulnar nerve, on the internal condyle of the humerus, amongst the tendons of the muscles which are there inserted. At this place it separates into a number of filaments: one passes to the articular capsule of the fore-arm with the humerus, and into the skin that covers the elbow; some proceed to the flexor muscles of the metacarpus. Two others, which are more remarkable and longer, follow the inferior margin of the wing under the skin, and are lost in the skin which covers the inner surface of the digiti. This nerve appears to supply the place of the *median*, the *ulnar*, and the *musculo-cutaneous*.

The other principal cord of the brachial plexus turns round the humerus to arrive at its superior surface, producing, at first, some very conspicuous filaments for the extensors of the ulna; then two other also very remarkable filaments, which are distributed in the form of a goose's foot under the skin, and the membranes situated between the humerus and the fore-arm. These branches appear analogous to the *nervus*

cutaneus

cutaneus internus. The trunk of the nerve continues to descend along the humerus; and, on reaching the articulation with the ulna, is found situated on the internal surface, but towards the radial edge of the fore-arm: it passes through the tendon of the *radialis externus* muscle, and upon arriving at the outer, or superior surface, divides into two branches; one, which is short, is lost under the skin that covers the external surface of the fore-arm; the other, which is longer, is situated between the two bones on the inter-osseous membrane. When it reaches the articulation of the carpus, it passes through a particular groove, and is seen divided into three filaments; a short one for the pollex, and the other two for the external side of each of the *digiti*, upon which they are distributed under the skin as far as the last joint.

It is evident that this cord corresponds to the *radial nerve*, and that one of its branches supplies the place of the *cutaneus internus*. This description is taken from the *duck* and the *stork*. We presume it is not different in the other birds.

D. *In Reptiles.*

In the *tortoise*, the three last pairs of cervical nerves, and the first of the dorsal, proceed to the thoracic member, where they form a plexus in the following manner: the fifth cervical pair passes

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behind the other four pairs, crosses them in their course, and unites with them in its passage. It then turns round the scapula, which in this animal is articulated with the first dorsal vertebra. We shall return to the description of this nerve. The sixth cervical pair proceeds directly along the scapula on its internal surface: it is crossed posteriorly by the fifth, and towards the lower third of the scapula receives the seventh cervical pair. The seventh is slender, crossed by the fifth and the first dorsal pair, and united with the sixth, in the manner we have pointed out. The first dorsal pair partly joins the seventh cervical, almost at the point where it comes out of the vertebral canal; it is then sent to the muscles of the shoulder.

We shall now pursue each of the cords we have mentioned to their termination.

The large nerve produced by the fifth cervical pair, having arrived behind and near the true articulation of the scapula with the spine, divides into three branches; one, which is but a filament, appears to be distributed to the articular capsule; a second, which is very flat, and from the sides of which a vast number of lesser branches extend to the muscles of the skin, appears to take the place of the *musculo-cutaneous*; the third branch, which accompanies the muscles of the scapula under the skin, descends to the humerus, without producing any remarkable branches. At this place, however, it sends off
several

several ramifications to the extensor muscles of the fore-arm. The trunk continues its direction forward, expands and loses itself under the skin, and may be followed as far as the hand : it may, perhaps, be regarded as supplying the place of the *ulnar* nerve.

The sixth pair of cervical nerves having, as we have shewn, assisted in forming the brachial plexus, passes along the internal surface of the scapula ; about the lower third of that bone it receives the seventh pair ; the nerve then becomes thicker, but soon after divides into two branches ; one, which is slender, passes into the groove, between the furca and the clavicle, and then spreads over the articular capsule of the humerus, after furnishing numerous filaments to the muscles which surround it ; this nerve may be regarded as analogous to the *articular* in man. The trunk of the nerve, which evidently supplies the place of the *median*, upon reaching the articulation of the humerus with the scapula, transmits filaments to the adjoining muscles. On arriving at the palmar surface of the fore-arm, it divides into three portions, two of which are on the ulnar side, and sink deeply into the muscles ; the third, which is much larger, follows the radial side of the fore-arm, and at the base of the thumb proceeds to the palm of the hand, and detaches filaments to each of the fingers.

The seventh cervical pair unites, as we have
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stated,

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stated, to the sixth, at the posterior part of the scapula, to form the median and articular nerves. We have therefore no occasion to return to its description. The first dorsal pair is lost in the muscles of the shoulder, and is not continued throughout the arm.

The brachial plexus of the *lizard* differs a little from that of the tortoise; it is formed by two dorsal, and the two last cervical pairs; the first of the cervical furnishes only one of its branches to the plexus; the other going to the neck.

In the *frog*, the nerves which are to be distributed to the arm, proceed from a very thick cord, which comes from between the second and third vertebræ: this makes the largest nerve in the whole body; it is soon after joined by a filament from the succeeding pair, with which it intimately unites; this cord proceeds towards the axilla—it sends off a branch, which passes above the shoulder, and is lost in the muscles of that part. The trunk continues its course to the arm, and very soon forms two principal branches; and besides these, it also sends some filaments to the extensors of the fore-arm, and the articular capsule of the head of the humerus.

Of these two nervous cords, one is directed forward upon the humerus, and represents the *median* nerve; it detaches some filaments to the muscles and the skin. Arrived at the fold of
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the fore arm, the nerve plunges amongst the muscles, along with the tendon of the *sterno-radialis*, which supplies the place of the biceps; it afterwards divides into two branches, placed one above the other: the most slender is situated between the flexor muscles of the fingers; the larger upon the furrow, which indicates the union of the two bones of the fore-arm; these pass under the ligaments of the carpus; having reached the palm, the superficial branch is lost in the skin which covers that part, and the deep seated is distributed to each of the fingers, nearly as in man. It also furnishes some filaments to the muscles of the hand.

The other cord represents the *radial* nerve; it turns round the humerus, and furnishes, in the first place, some branches to the extensor cubiti: continuing to descend round the humerus, it arrives before the articulation with the bone of the fore-arm, on the radial side—it passes through the substance of the muscles to the external part of the fore-arm: it is afterwards divided; one of the branches is lost under the skin, the other passes under the back of the hand, and terminates on the convexity of the fingers. From this description it will appear, that the nerves of the arm in frogs very much resemble those of the wing in birds.

In the *salamander* the nerves of the arm are distributed as in the frog, but the brachial plexus is formed by two cervical, and two dor-

fal pairs, if we may regard as dorsal vertebra those which sustain rudiments of the ribs.

There are no brachial nerves in *serpents*.

E. *In Fishes.*

The nerves of the pectoral fin of spinous fishes proceed from the two first vertebral pairs; these two nerves arise at a considerable distance from each other, and traverse the first muscle placed between the spine and the first rib, which seems analogous to the scalenus.

In the *salmon* the anterior nerve approaches the par vagum, of which it might be regarded as a branch, were it not observed that it comes out through a particular foramen. In the *carp* it is separated by the last branchial bone. The second vertebral pair, intended for the shoulder, is situated more posteriorly, and nearer to the middle line of the body, behind the œsophagus. These two nerves proceed directly downward to the internal lamina of the scapula, where they re-unite, but are not confounded. The first vertebral pair then divides into two cords, from which anastomosing filaments are detached to form a kind of plexus. A number of these filaments are distributed to the adductor muscles of the fin. The cord, which is given off from the first vertebral pair, likewise appears to terminate in these muscles; but it previously produces a remarkable filament, which is distributed

buted to the membrane that separates the brachial from the thoracic, or abdominal cavity, which are here confounded. May not this filament be regarded as analogous to the *diaphragmatic* nerve? we are much inclined to this opinion.

The two brachial nervous cords pass through the hole situated before, and without the articulation of the fin with the shoulder; they unite there, and produce an irradiation of nervous filaments, several of which are lost in the muscles of the external surface of the shoulder, and in the oblong articular capsule which receives the small carpal bones. Lastly, one of the filaments extends under the skin, which forms the membrane of the radii of the fins.

In cartilaginous fishes, as the *rays*, both the distribution and number of the brachial nerves are very various. The first twenty vertebral pairs are received in a cartilaginous canal, behind the cavity of the branchiæ; they unite there, and form a large single cord, which extends towards the middle part of the fin, crossing the cartilaginous bar, on which the radii are articulated.

This first cord continues its direction forward, along the cartilaginous bar, describing an arch, the concavity of which is anterior, and gives origin to a number of filaments, equal in number to the radii of the fin. All these filaments

are lost in the muscles, and may be followed to the margin of the fin.

The four or five vertebral pairs, which succeed the first twenty, likewise unite into a thick cord, which is afterwards subdivided into seven or eight filaments, for the middle radii of the fin. These are almost perpendicular to the medulla spinalis.

The pairs of vertebral nerves which follow to about the forty-fourth, unite two and two, and form a cord, which perforates the cartilaginous bar of the posterior part of the fin; they divide in the muscles in the same manner as the preceding.

The nerves of the pectoral fin, or wing of the *ray*, therefore, present a very singular distribution.

ARTICLE XV.

Of the Nerves of the Abdominal Member.

A. In Man.

IN describing the lumbar and sacral nerves, we pointed out the formation of the principal trunks that are distributed to the inferior extremity: we now proceed to trace them particularly.

1. *Of*

1. *Of the Subpubic, or Obturator Nerve.*

This nerve arises from the plexus of the lumbar pairs. The place at which it is separated varies; it proceeds into the small pelvis, along the inner side of the tendon of the psoas muscle, and is directed towards the subpubic foramen: it furnishes some filaments to the internal obturator muscle; it then passes through the subpubic foramen, and sends off some filaments, which go to the external obturator muscle; after which, it divides into two branches, one anterior, the other posterior.

The first is lost in the pectineus, gracilis, and cruralis muscles; it descends almost to the knee.

The posterior branch is distributed nearly in the same manner, but is more deep seated.

2. *Of the Anterior Femoral, or Crural Nerve.*

This cord is commonly formed by the plexus of the four first pairs of lumbar nerves; it accompanies the femoral artery in its course through the small groove, which the iliacus and psoas muscles leave between them, to which it gives some filaments. When under the inguinal arch, it divides into a considerable number of branches destined for the muscles.

One branch is usually sent to the rectus muscle; four or five to the triceps femoris; some to the sartorius, several of which afterwards proceed under the skin. Lastly, others are
distri-

distributed to the fascia lata, the pectineus, the gracilis, and the semi-tendinosus.

Two longer filaments proceed under the skin of the thigh, on the internal side: one, which nearly follows the direction of the femoral artery, spreads out at the knee; the other is considerably thicker; it descends to the foot, nearly accompanying the vena saphæna, and is called *nervus saphænus*; it frequently receives a branch from the subpubic nerve towards the middle of the thigh; it is chiefly distributed to the skin.

3. *Of the Ischiatic, or Sciatic Nerve.*

This is the largest nerve in the body; it is usually produced by the two last lumbar, and the three first sacral pairs: it issues from the pelvis, between the gemini and pyriformis muscles, through the ischiatic notch; it there produces some filaments for the obturator internus, the gemini, and quadratus femoris. In this posterior situation, it descends from the ischiatic tuberosity towards the trochanter. Having reached the middle of the thigh, or somewhat lower, it divides into two cords, which continue to descend and pass into the ham; they then assume the names of the *popliteus internus*, or *tibial nerve*, and the *popliteus externus*, or *peroneal nerve*.

In its course along the thigh, the ischiatic nerve furnishes also a number of small branches
to

to the semi-tendinosus, semi-membranosus, and biceps, and to the adductors of the thigh.

When in the ham, it sends filaments to the popliteus, semi-tendinosus, biceps, and gastrocnemii muscles.

It also frequently produces a branch which sometimes arises from the lower part of the peroneal nerve. This branch proceeds under the muscles of the tendo Achillis, on the side of the fibula. It is distributed to the skin of the foot, and is sometimes continued on the back of the foot, as far as the extremities of the toes.

4. *Of the Tibial Nerve, or Popliteus Internus.*

This is the internal portion of the trunk of the sciatic nerve, after it reaches below the ham: the cord, which it forms, passes under the muscles which compose the calf of the leg, to which it sends some ramifications. It likewise furnishes some to the popliteus muscle, and its filaments accompany the tibial artery, properly so called, or that which enters the bone; it likewise detaches filaments to the tibialis posterior, flexor longus pollicis pedis, and flexor communis digitorum pedis. The trunk, continuing to descend, proceeds towards the internal malleolus; it enters the groove formed between the tibia and the os calcis, along with the tendons of the flexor muscles. When arrived under the sole of the foot, it is divided into the *internal and external plantar nerves*; the first

first transmits filaments to the small muscles of the foot, as the short flexors, transversales pedis, and the abductors and adductors of the great toe, and afterwards divides into four branches, which are distributed to the lumbricales and interossei muscles, and to the skin: the ramifications which go to the latter, are disposed of in the same manner as the branches of the median nerve in the hand, forming also an arch with the external plantar.—The external plantar nerve supplies the fifth toe, and external side of the fourth.

5. *Peroneal Nerve, or Popliteus Externus.*

The external branch of the sciatic nerve assumes this name below the ham: at first it detaches some filaments, which are extended forward under the skin of the leg and foot, and which unite with the cutaneous ramifications of the tibial nerve. It afterwards glides along the fibula, and making a curve at the superior third of that bone, is there divided into three branches, two of which are superficial, and the other deep seated.

The deep-seated branch is distributed to the muscles of the anterior part of the leg; it extends under the skin of the knee and foot, transmitting filaments to the extensor brevis, and the superior interossei muscles.

Both the superficial branches proceed under the aponeurosis of the leg: the first rises from
it

it towards its middle part, and passes in the skin as far as the foot ; the second likewise pierces the aponeurosis, about the middle of the leg, and proceeds under the skin, towards the malleolus externus : when it reaches the foot, it divides into several filaments, which, like the preceding, terminate on the lateral part of each of the toes.

B. In other Mammiferous Animals.

The lumbar and pelvic nerves, destined for the abdominal member, form a plexus previously to their distribution. In general it is the same as that which takes place in man, or the differences are unimportant. The nervous cords are precisely alike in number, and divide in the same manner.

The anterior crural nerve arises most commonly before the subpubic. In the groin it produces an irradiation of muscular filaments ; one, which is very remarkable, accompanies the vena saphæna under the skin, and may be traced to the foot.

The subpubic nerve also passes through the foramen obturatorium ; it is distributed to the muscles of the thigh.

The sciatic nerve is also produced by the sacral pairs ; it commonly receives anastomosing filaments from the caudal pairs. In general, it

presents no essential difference from the same nerve in man.

C. *In Birds.*

The *obturator* nerve also arises, in birds, from the plexus, formed by the lumbar pairs; it goes through the subpubic hole, with the tendon of the obturator internus; soon after it leaves the pelvis, it divides into a great number of branches, which terminate in the muscles that surround the os femoris, and chiefly in those about its articulation, and in the adductor muscles.

The *femoral* nerve is evidently formed by the three last lumbar pairs, which compose a plexus above the pelvis, from which the obturator nerve proceeds. On reaching the groin, the crural nerve separates into three principal branches, which afterwards divide and sub-divide in the different muscles of the anterior and internal surface of the thigh. A considerable number terminate in the skin, on which they may be very easily traced.

The *sciatic* nerve is produced in birds, chiefly by the four superior pelvic pairs; it proceeds towards the sciatic notch of the pelvis, behind the cotyloid cavity. Having left the pelvis, it divides into two principal portions; the posterior is a fasciculus, composed of seven or eight branches, which are lost in the glutei muscles
and

and adductors of the thigh. The other portion is a simple and very thick cord, which appears to be the trunk of the nerve itself. It takes the direction of the former, and detaches some slender branches, which are distributed to the flexor muscles of the leg. When arrived at the middle and posterior part of the thigh bone, the trunk divides into two branches; the larger corresponds to the *tibial* nerve, and the other, which is smaller and nearer the bone, appears to be the *peroneal* nerve.

When the tibial gets into the ham, it divides into two branches: the thicker of the two separates into six or seven filaments, destined to the muscles of the posterior part of the leg, and chiefly to the gemelli and the soleus; the other branch continues to proceed behind the bone of the leg; having reached the heel, it enters a groove, and passes under the bones of the metatarsus, at the digital extremity of which it divides into four, three, or two portions, according to the number of the bird's toes: these filaments are sent to the peroneal edge of each of the toes.

The *peroneal nerve*, or the second principal branch of the sciatic, is, as we have observed, nearest the bone. When it arrives under the knee, it passes towards the peroneal edge of the leg, and divides into a number of filaments, which are lost in the anterior part of the leg. Two filaments, which are much thicker and
longer,

longer, accompany the bones of the leg; one on the peroneal edge, the other on the tibial; in this manner they pass above the articulation of the tarsus, in two grooves, which are proper to themselves: they approach each other afterwards, and are situated in the anterior gutter of the metatarsal bone, after which they again separate. The tibial branch passes between the second and third toe, and the peroneal between the third and fourth, when the latter exists; they proceed along the edges of the toes, and terminate under the skin, near the nail. This description is taken particularly from the *flork*, though we have made similar researches in several other birds; it shews that the nerves of the abdominal member are nearly the same in birds as in man.

B. *In Reptiles.*

In *lizards* there is only a small nervous filament, which proceeds from the femoral nerve, and supplies the place of the *subpubic*. The *femoral* nerve is itself formed of the two last lumbar pairs, and passes above the bones of the pelvis, to be distributed in the muscles of the anterior part of the thigh. The *sciatic* nerve is produced by the three pairs of nerves which follow, and which also receive a filament from the last lumbar pair; the only cord they form, proceeds along the inside of the thigh, subdividing

dividing in the muscles, and extending to the toes.

The distribution of the nerves in the abdominal member is nearly the same in the *salamander*: there are no differences except in the manner in which the plexus is formed. The *femoral* nerve is produced by a single lumbar pair, which transmits a branch to the sciatic plexus, formed by the two succeeding pairs.

In the *frog*, three pair of nerves enter into the composition of the femoral plexus, before which they run the whole length of the ossa ilii, which are very long: when arrived at the thigh, the plexus sends off a nerve which corresponds to the *anterior femoral*; it is distributed in radiated filaments to the fore part of the thigh. The rest of the plexus proceeds into the pelvis, and forms a large cord, which passes to the posterior part of the thigh, and may be regarded as the *sciatic* nerve. A great number of filaments are afterwards detached from it to the muscles; about the middle and posterior part it divides into two branches, which pass under the ham, and represent the two *popliteal* nerves, the *external* and *internal*: these are afterwards distributed to the foot of the posterior leg, nearly in the same manner as to the human foot.

E. *In Fishes.*

The ventral fin, which, in fishes, represents
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the posterior extremity, receives nerves from the vertebral pairs.

In the cartilaginous fishes, as the *ray*, eight or nine pairs proceed directly outward towards the ventral fin; the four or five first pairs unite into one trunk, which passes through a particular hole in the cartilage that sustains the radii. The other pairs proceed immediately above the radii. All these nerves are distributed to the muscles, precisely in the same manner as in the pectoral fin.

In the spinous fishes, of which we shall mention the genus *Silurus*, the vertebral pairs, which are distributed to the intercostal muscles, detach filaments to the muscles that move the fin. Some of these may be distinctly followed to the membrane which covers the radii.

ARTICLE XVI.

Of the Great Sympathetic, also called the Great Intercostal or Tri-splanchnic Nerve.

A. In Man.

THIS nerve cannot be considered as proceeding immediately from the brain. It communicates with the fifth and sixth pairs of the encephalon, with the thirty pairs of vertebral nerves, with
the

the glosso-pharyngeus, and with the par vagum. At all these points of communication it exhibits very remarkable enlargements.

The portion of the great sympathetic, which is nearest the brain, appears in the carotid canal of the os temporum, where it forms a plexus round the carotid artery. We have already pointed out the filaments which unite this nerve to the sixth pair, and that which it appears to receive from the spheno-palatine ganglion of the maxillaris superior, under the name of the vidian nerve.

The nervous filaments of the carotid plexus form, at the base of the cranium, a single trunk, which produces an elongated enlargement of a reddish colour; it extends nearly to the third vertebra, and is called the *superior cervical ganglion*.

This ganglion receives filaments at its origin from the first and second cervical pairs; sometimes from the glosso-pharyngeus and the pneumo-gastric; to which, as well as to the carotid artery, it is always joined by a very compact cellular substance. Its figure is an oblong oval, more pointed inferiorly.

After this enlargement, the trunk of the nerve, which becomes more slender, descends long and behind the carotid artery, as far as the inferior part of the neck, where it forms a new ganglion, named *the inferior cervical*. In its course it receives or detaches filaments to each

of the cervical nerves at its posterior part. It gives off others from its anterior part to the pharynx and the fat, the fibrils of which uniting together, produce very delicate plexuses round the carotid arteries; the muscles of the anterior part of the neck also receive many filaments. Lastly, among the other ramifications, which, in consequence of their tenuity, cannot be readily traced, we observe some which, uniting with filaments from the par vagum, pass into the thorax, and form the inferior cardiac plexus, as we have shewn in describing the pneumo-gastric nerve.

The *inferior cervical* ganglion is flat. Its figure varies. It is oblong, triangular, or square in different individuals. It is usually situated before the transverse process of the seventh vertebra of the neck. It is sometimes wanting, and then it is confounded with the first thoracic ganglion. It commonly receives filaments from the four last cervical pairs, but seldom any from the dorsal. It appears to produce others which, proceeding to the internal side, join the recurrent branch of the par vagum, the diaphragmatic nerve, and the nerves which form the superior and inferior cardiac plexuses.

The trunk of the sympathetic nerve enters the thorax behind the vertebral artery. Having arrived upon, or a little below the head of the first rib, and still covered by the sub-clavial artery, it experiences a new enlargement, called the
superior

superior thoracic ganglion. A number of nervous filaments run into this ganglion from the inferior cervical pairs, among which there is always a very remarkable one from the first dorsal pair, and even sometimes another from the second. It produces three orders of branches. The first unite with the cardiac plexus; the second form a plexus round the sub-clavial and vertebral arteries; the others are lost in the muscoli scaleni and longus colli.

The remaining part of the great sympathetic nerve, in the cavity of the thorax, is somewhat thicker than in the neck. It is attached inferiorly to the pleura, and passes above the heads of the ribs. In its course, as far as the diaphragm, it receives filaments from the dorsal pairs, at acute angles; at each of the points of union it forms enlargements or ganglia, which are named in numerical order. They vary both in form and size.

At the sixth ganglion five or six branches are usually detached from the nerve. They proceed downward and inward towards the bodies of the vertebra. They are there united, and form a particular cord, which passes into the abdomen, through an aperture of the diaphragm, to which muscle it affords filaments. This cord is called the *splanchnic nerve*.

Upon getting into the abdomen, the splanchnic nerve becomes almost immediately flat, and forms a kind of nervous crescent before the

U 3
aorta.

aorta. From its form this has been named the *semi-lunar ganglion*. It is joined inferiorly to that of the opposite side. It sends off a great number of filaments. Some go to the diaphragm, a number of others form a plexus round the aorta, and the renal, cœliac, and superior mesenteric arteries.

That which envelopes the cœliac artery is particularly named the *solar plexus*. It receives a number of filaments from the par vagum. The others, from their situation with respect to the arteries, are called the *coronary stomachic*, the *splenic*, and the *hepatic plexuses*.

The trunk of the great sympathetic, which we left in the thorax, continues to descend to the diaphragm, but it detaches, at the ninth and tenth thoracic ganglion, and sometimes at the last but one, a filament called the little *splanchnic nerve*, which unites with the great splanchnic in its passage through the diaphragm.

The situation of the great sympathetic within the abdomen is nearly the same as in the thorax. It forms enlargements at each lumbar vertebra, which receive two or three filaments from each of the lumbar pairs. It also sends filaments to the plexuses already described; there are then plexuses formed round the inferior mesenteric, spermatic, and hypogastric arteries, which are termed *inferior mesenteric*, *spermatic*, and *hypogastric plexuses*. The last of these transmits branches to all the adjoining arteries,

series, to the colon and rectum, to the ureters, the bladder, and the parts of generation.

Having reached the pelvis, the great sympathetic proceeds to the os sacrum. Arrived at the caudal vertebræ, the two trunks, which are now very slender, unite and form the last ganglion. In this course there are as many enlargements as there are sacral nerves. It happens, however, sometimes, that there is no ganglion.

In this manner the great sympathetic nerve terminates in man.

B. *In other Mammiferous Animals.*

The great sympathetic nerve of the other Mammalia is nearly similar to that of man. We shall give a description of it, taken from accurate dissections in the *wolf*, the *raccoon*, the *porcupine*, the *sheep*, and the *calf*.

The great sympathetic evidently unites, within the cranium, and in the folds of the dura-mater, with the fifth and sixth pair of nerves. This anastomosis is very remarkable.

On entering the cranium through the foramen lacerum, it is very distinct from the par vagum, but it adheres closely to the periosteum of the temporal bone. When we stretch the cord which it forms, we observe that it is divided into six or seven filaments, which make together a very compact net-work. Two or three lines farther, according to the size of the animal, all

these filaments approach each other, and are again united so intimately, that the ganglion which they produce appears, by its section, cartilaginous. Numerous filaments proceed from this ganglion, some of which are very short, and are sent to the nerve of the fifth pair. Others, which are longer and smaller, form a kind of reddish coloured net, interlaced with blood vessels. This is the net which Willis regarded as a little *rete mirabile*. It appears that the communication with the sixth pair takes place by means of this net, which envelops the nerve on every side, and from which it is separated with great difficulty. We have not remarked any particular anastomosing branch in the *calf*, or in the *ram*.

In its course through the foramen lacerum, the great sympathetic nerve detaches a nervous filament which enters the cavity of the tympanum. It is also there intimately united with the eighth pair, from which it separates at the base of the cranium to form a thick cord.

Having advanced some lines from the cranium, the great sympathetic swells into a large reddish ganglion of an elongated oval form. This is the *superior cervical ganglion*. It unites with the neighbouring nerves in the same manner as in man.

After communicating, by filaments, with the adjoining nerves, the superior cervical ganglion proceeds to the anterior part of the neck, before

the longus colli muscle, as far as the seventh vertebra. In its course it receives very slender nervous filaments from all the cervical pairs.

In the front of the last vertebra of the neck, it forms a curve, which is directed from within outward towards the first rib, on the head of which it unites with the first thoracic ganglion.

Several filaments which go from the convexity of this curve, proceed along the mediastinum to the pericardium, where they are lost. Others form a plexus around the subclavial artery.

The first thoracic ganglion is of a semi-lunar figure, more or less elongated according to the species. Its concavity is inward. On its conical edge it receives or transmits four or five filaments. The most superior passes along the vertebral artery, accompanies it into the canal, and forms around it a plexus which may be followed very high up, and which probably enters into the cranium with the artery. The other filaments unite with the last cervical, and with the two first dorsal pairs.

From the concavity or superior and internal edge of this first thoracic ganglion, one, two, or three filaments are detached, which proceed transversely or obliquely downward towards the pulmonary arteries at their entrance into the lungs; they there unite with the par vagum, to form the *pulmonary* and *inferior cardiac plexuses*.

The trunk of the great sympathetic continues

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nues to descend in the thorax as far as the diaphragm. In its passage it forms a ganglion upon the head of each rib, which receives a nervous filament from each of the vertebral pairs. Lastly, it passes through the diaphragm, forming a single cord, which is the real *splanchnic nerve*.

On entering the abdominal cavity, the splanchnic nerve proceeds towards the middle line under the stomach: it is there frequently divided into two cords, which afterwards rejoin. From this kind of nervous ring there arises either a principal trunk, or four or five filaments, which uniting together near the cœliac artery, form a ganglion which is frequently of a semi-lunar figure. A number of filaments proceed from the edges of this ganglion, and envelope the stomachic, splenic, and hepatic arteries, and supply the place of the solar plexus; others envelope the renal artery, round which they also form a plexus,

The trunk of the great sympathetic still descends in the abdominal cavity, on the lateral parts of the bodies of the vertebræ: each of its ganglia is nearly of an elongated quadrangular form; one of the superior angles receives the continuation of the trunk; the other the vertebral pair. The internal inferior angle transmits a branch to the aorta, which assists in forming some of the plexuses that surround each of the arteries which rise from that vessel. The
other

other angle produces the continuation of the trunk.

In other respects the great sympathetic appears to be disposed in all mammiferous animals as in man : it produces the same plexuses, with some differences as to the number of filaments and the shape of the ganglia : but even these circumstances are subject to variation.

C. *In Birds.*

The great sympathetic in birds has many resemblances to that in mammalia : It enters the cranium by the same aperture as that through which the par vagum and glosso-pharyngeus come out ; it also unites with the fifth and the sixth pairs. The first ganglion, or that which corresponds to the superior cervical, is of a lenticular form ; it is situated immediately below the cranium, and communicates with the ninth pair, and particularly with the eighth, with which it appears to be altogether confounded.

We find no trace of the great sympathetic in the neck of birds ; but within the thorax we observe that it detaches to the pulmonary plexus, formed by the par vagum, a very thick nervous filament, which is united to the first thoracic ganglion.

Here the great sympathetic of birds begins to assume an appearance truly remarkable.

The

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The first nervous ganglion becomes a centre from which eight different diverging filaments proceed. The first unites to the plexus of the brachial nerve; the second descends the neck in the vertebral canal along with the artery, and at the middle of each vertebra forms a small ganglion, from which filaments are sent off to each of the cervical pairs. We have found it impossible to follow it as far as the head, in the *coot*, the *duck*, the *swan*, and the *buzzard*. The third filament is confounded with the cardiac plexus formed by the par vagum. The three next filaments proceed from the internal side towards the projection made by the bodies of the vertebræ, and produce a particular cord, to which we shall return. Lastly, the seventh and eighth filaments serve to unite this ganglion with the succeeding one; the one passing below, and the other above, so as to form a curvature of a lozenge-like shape, in which the head of the rib is received.

Each succeeding ganglion produces, in this manner, a nervous irradiation, composed of five, six, or seven filaments; four of which, two superior and two inferior, communicate with the preceding or following ganglion. By one or two a nervous cord is formed, which supplies the place of the splanchnic nerve: the last filament unites with the dorsal pair situated inferiorly.

The cord which is produced by all the internal branches of the great sympathetic, and which

is analogous to the splanchnic nerve, accompanies the aorta on each side. Having reached the part where the cœliac artery divides into three, it is united to nervous filaments derived from the thoracic ganglion, and thus forms one, two, or three enlargements, which detach an immense number of branches to envelope the arteries on all sides. The ganglia here obviously supply the place of those named semi-lunar in man, and the filaments which proceed from them answer to the solar plexus. There are also other plexuses formed on the renal and inferior mesenteric arteries.

The trunk of the nerve continues to follow the bodies of the vertebræ, but the ganglia become less conspicuous when there are no longer any ribs, and we there perceive only a small enlargement at the point where the vertebral pair is united. But from the internal side of each of these small enlargements, two or three filaments are detached, and produce a plexus on the aorta, anastomosing with those of the opposite side.

We clearly perceive the continuation of the great sympathetic nerve to the last vertebra of the tail. It is very easily traced in the *swan*.

D. *In Reptiles.*

We have had no opportunity of dissecting the great sympathetic nerve of reptiles, except in
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the *mud-tortoise*. It is only distinct in the interior of the back shell: it has a disposition analogous to that of the cervical ganglion. The pneumo-gastric nerve, however, adheres so closely to it, that they cannot be separated: we did not perceive any filament on the neck which could be regarded as the trunk of the nerve.

On the peritoneum, and on the bodies of the vertebræ, there appear very distinct nervous ganglia, which are manifestly produced by the great sympathetic.

The ganglia are exactly similar to those of birds. There are two superior and two inferior filaments which pass under the transverse process of the vertebra that is united to the back shell; from the internal edge of each ganglion, a splanchnic nerve proceeds, which forms plexuses round each of the arteries produced by the aorta: one is also sent to assist in forming the pulmonary plexus.

This nerve may be very easily traced to the lateral parts of the first vertebra of the tail.

E. *In Fishes.*

We also find the great sympathetic nerve in fishes, but it is exceedingly slender: it is a simple nervous filament, situated on each side of the vertebral column in the abdominal cavity. It evidently furnishes filaments to the peritoneum, which extend round the arteries that
are

are lost on the intestines. We also observe that there are communicating filaments for each of the vertebral pairs, but there are no apparent ganglia at the points where this union takes place.

The great sympathetic nerve appears to enter the cranium by the canal of the first vertebra ; it there accompanies the blood vessels.

LECTURE ELEVENTH.

DESCRIPTION OF THE NERVOUS SYSTEM OF
ANIMALS WHICH HAVE NO VERTEBRÆ.

ANIMALS without vertebræ are not formed on a common plan either with respect to the nerves or the muscles: they present disparities so great that we are compelled to adopt a mode of description different from that pursued in the three last Lectures. It is necessary to proceed in the same manner in which we have treated the organs of motion in these animals. We must consider the nervous system in their different classes, and in their principal genera. As the characters common to each of these classes are very few, what we have said on that subject, in Lect. I. Art. 3 and 5, and in Lect. IX. Art. 3, will suffice, and we now proceed to enter into details.

ARTICLE I.

*Brain and Nerves of the Cephalo-podous
Mollusca.*

IN the *eight-armed sepia*, the *cuttle fish*, and the *calmars*, the nervous system appears to resemble
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in some respects that of red blooded animals. The brain is inclosed in a particular cavity of the cartilage of the head, which is pierced by a number of holes to give passage to the nerves.

The cartilage of the head has the form of a hollow and irregular ring; its posterior part is the thickest, and contains the brain; its anterior part contains the ears, and a semi-circular canal which communicates on each side with the cavity of the brain, and includes the medullary collar. The œsophagus passes through the centre of this cartilaginous ring, and is consequently, as in all white blooded animals, surrounded by the medullary cord. The lateral parts of the cartilaginous ring have eminences which form a kind of orbit on each side.

The brain is divided into two distinct parts; one next the œsophagus, the surface of which is smooth; and the other towards the back, which is round, and marked by longitudinal striæ.

The medullary collar arises from the lateral parts of both portions: in the *octopus* it is in the form of a lamina; the anterior part of which produces four large nerves, which, with the four corresponding nerves, proceed forward into the eight feet which crown the head: we shall return to their distribution. These laminæ join inferiorly, and thus encircle the œsophagus.

Two other principal pairs of nerves arise from each side, near the origin of the collar. The

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first is the optic pair : it extends directly into the orbit ; after a short course it passes through the sclerotic coat, and is there dilated into a ganglion larger than the brain, and which has the form of a kidney with its concave side turned towards the brain. The substance of this ganglion appears to be the same as that of the brain ; its convexity produces a multitude of small nerves, as fine as hairs, which pass through the choroides, by an equal number of small holes, to form the retina.

The second pair belongs to the muscles of the sac ; it originates a little above the preceding pair : these nerves descend obliquely ; and, after leaving the cerebral cavity, each slips between the muscles which sustain the head, and is sent to the lateral part of the sac, near its superior edge, between the body and the branchiæ ; it there divides into two branches, one of which descends directly towards the bottom of the sac, and the other dilates into a roundish ganglion, which produces a multitude of nerves, disposed like radii. These nerves are distributed to all the fleshy fibres of the sac and the fins.

The anterior and inferior part of the collar gives origin to two pairs of nerves. The first pair is the auditory nerves ; they are very short, as they only traverse a cartilaginous lamina to penetrate the ear, where they are distributed.

The second pair issues from the cartilage, by two holes placed very near each other, and beneath

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neath the ears : the two nerves which compose it descend within the peritoneum to the bottom of the sac. When they arrive near the heart, they form a complicated plexus, from which all the nerves of the different viscera proceed.

Each foot has a nerve, which passes from one extremity to another, like an axis, and is situated in a canal, which we described when we treated of the Muscles of the Feet. This nerve is enlarged, at different spaces, by numerous ganglia, which have the appearance of tubercles, and from each of which ten or twelve nervous filaments proceed : these filaments diverge and perforate the muscles of the interior of the foot to which they distribute branches ; but they proceed chiefly to the suckers.

This description of the nervous system is taken from the *sepia octopus*. The other Cephalopoda differ only in having a brain less distinctly divided, and presenting less conspicuous furrows.

ARTICLE II.

*Brain and Nerves of the Gasteropodous Mollusca.*A. *In the Snail (Helix Pomatia.)*

THE brain of the Snail is situated upon the œsophagus, behind an oval mass of muscles, which envelopes the mouth and the pharynx, and which we shall describe in the Article on Mastication; its shape is nearly semi-lunar, with its concave part directed posteriorly. The angles of the crescent are prolonged on each side into a branch, by which the œsophagus is encompassed in a collar. The salivary glands, and the muscle which retracts the mouth and brain, pass likewise through this collar.

The two cords produced by the brain unite below the œsophagus and the muscle, in a large round ganglion, which is more than one half the size of the brain. All the nerves proceed from one or other of these two masses.

Those furnished by the brain proceed from the lateral parts of its convex side.

There are, in the first place, two nerves for the fleshy part of the mouth; next, one on each side for the small horns; then two for each great horn, one of which proceeds to the base of that horn, and passes into its muscular substance; the

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the other goes to the eye. The latter is folded considerably on itself, when the horn is drawn inward. There are, besides, some other filaments which extend to the base of the parts of generation, and to the muscles which move the head.

The large inferior ganglion produces, at first, three great nerves, one for the penis, another for the viscera, and the third for the muscles, which draw the whole animal into its shell: the inferior surface of this ganglion afterwards produces two great fasciculi, which proceed backward, and which, after passing between the two muscles before mentioned, are distributed to all the fleshy parts of the foot.

The figure which Swammerdam gives of the nerves of the snail, appears to have been taken from the slug, rather than from the shell snail.

B. *In the Slug (Limax Rufus.)*

The brain is also situated behind the œsophagus in this animal, but it has the form of a narrow ribbon lying cross ways: it enlarges a little at its lateral parts, each of which produce a filament to encircle the œsophagus. The ganglion which is formed by the union of these two filaments is larger than the brain.

Two principal trunks proceed, each on its respective side, in a straight line from this ganglion; they extend along the lower part of the body,

throughout its whole length, preserving nearly a parallel direction; on the external side they each detach a number of filaments, which penetrate into the fleshy substance of the skin.

A great number of other filaments also proceed immediately from the inferior ganglion to the skin.

Further, the inferior ganglion sends off two nerves on each side, which go to the viscera, and take the distribution of the arteries.

With respect to the brain, properly so called, it furnishes, in the first place, a nerve from each side, for the fleshy mass of the mouth; then two for each of the great horns, one of which extends to the eye, and becomes the optic nerve. The nerves of the small horns arise more outwardly.

C. *In the Aplysia.*

This is a small marine animal, very like the slugs, but respiring through branchiæ, which form a kind of tuft on the back, and which are covered by a particular operculum.

The brain is situated as in the snail; but the branches which surround the œsophagus produce two ganglia, one on each side, which are conjoined by a small filament.

The brain furnishes, at its anterior part, two slender filaments, which encircle the fleshy mass of the mouth, and unite under it in a small ganglion,

ganglion, whence the nerves of the lips are detached. The brain afterwards affords nerves to the horns and the eyes, which are, in this animal, situated between the horns, and to the male parts of generation. The two lateral ganglia transmit a multitude of nerves to all the fleshy parts of the foot and skin; they also produce each a long cord, which unites to its corresponding cord on the aorta, near the part where it rises from the heart; they there form a lenticular ganglion, from which all the nerves of the different viscera proceed.

D. In the Clio borealis.

This small animal has no foot, and can only swim. It respire by two branchiæ, in the form of wings, situated on the neck; but in other respects it very much resembles the slug. Its nervous system is analogous to that of the aplysia.

Its brain is formed of two roundish lobes; it furnishes, immediately, nerves to the tentacula, and gives origin to a double collar; the anterior extends, as in the aplysia, under the mouth, to form a small ganglion. The posterior has a ganglion on each side, which furnishes nerves to the muscular skin that surrounds the body; each of these produce one or two other ganglia, which send nerves to the viscera.

E. *In the Doris.*

This is also a small marine animal similar to the slug, but it respire by external branchiæ, disposed like stars round the anus. The brain is very large in proportion to the rest of the body, and particularly in comparison with that of other gasteropoda: it is contracted at its middle part, and seems to form two united lobes; it is elongated transversely, and of a square form. It is situated immediately above the origin of the œsophagus, behind the orbicular mass of muscles which form the parietes of the mouth.

Six nerves proceed from the brain on each side; one pair is destined for the muscles of the mouth, another for the tentacula. The third is a cord, which passes below the œsophagus, and is lost in the muscles of the foot, where it may be very distinctly observed on the lateral parts of the internal surface. The fourth and the fifth are directed above the mass of the intestines, and proceed to the skin of the back. Lastly, the sixth terminates in the parts of generation.

F. *In the Scyllæ.*

This is another marine animal similar to the slug, but which respire by branchiæ, in the form of wings ranged in pairs on the back; it
crawls

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crawls on a furrow in its belly. The collar which surrounds the œsophagus is a simple cord, and does not enlarge into a ganglion, as it proceeds downward. The brain, which is above it, is of an oval form : it sends nerves to the mouth, and to the horns, but there are no optic nerves, as this animal has no eyes.

The nerves of the viscera arise from the inferior part of the collar, and those of the muscles from its sides.

G. *In the Sea Ear (Halyotis Tuberculata.)*

This animal has no ganglion above the œsophagus to supply the place of the brain. We find merely a nervous filament, situated transversely above the œsophagus, behind the mouth. Four small ramifications proceed from the middle and anterior part of this filament, two on each side, and are lost in the parietes of the mouth.

At each extremity of the transverse nervous filament there is a very large flat ganglion, from the circumference of which a number of nerves are detached to the adjacent parts. These we shall describe.

Three filaments pass off on each side ; from the external surface of this ganglion one is sent to the setiform tentaculum, situated above the mouth, the other two proceed to the flat tentaculum, like a buckler, placed more posteriorly,

riorly, and on the sides. The most posterior appears to be intended for the eye. It is the thickest; the other seems lost in the muscular parts.

A very remarkable filament is detached from the superior part; it proceeds above the œsophagus, and joins the corresponding one of the other side. There is a small enlargement at the point of union, from which four nerves proceed, two on each side of the middle line. The most external is lost in the muscles of the tongue; the other pursues the middle line of the œsophagus, and is ramified over the intestines.

Several small branches are detached inferiorly, and terminate in the fan-like muscles that sustain the tongue.

Lastly, the ganglion is prolonged posteriorly into a thick nervous cord, situated on the sides and below the œsophagus, which becomes flat as it proceeds backward: it describes a semi-lunar curve, so that the two nerves of each side are approximated, and finally touch each other at the base of the tongue, and below the anterior part of the large muscle which attaches the animal to its shell.

The contact of these two nerves produces a ganglion, from which two very remarkable trunks, intended for the intestines, proceed; they may be followed to above the stomach, and we can perceive that some of their ramifications enter the liver.

After

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After the formation of the ganglion, which furnishes nerves to the viscera, the two trunks penetrate by two different holes into the substance of the muscle of the foot. These two holes are the origin of two canals, which run throughout the whole length of the foot, on the sides of another middle canal, which appears destined to distribute the blood of the animal.

The two nerves, lodged in the lateral canal, are distributed by a great number of lateral holes into the substance of the fleshy muscles of the foot, and of the shell, where they may be followed with facility.

H. *In the Bulimus of Ponds (Helix Stagnalis Lin.) and in the Planorbis Cornea (Helix Cornea Lin.)*

In these animals the brain consists of two lateral masses, separated by a contraction. The recent subject is remarkable for having these masses of a lively red colour. The distribution of the nerves differs very little from what we observe in the common snail.

ARTICLE III.

Brain and Nerves of the Acephalous Mollusca.

THE nervous system of Acephalous Mollusca is formed on a plan far more uniform than that

of the Gasteropoda. In all the testaceous acephala, from the *oyster* to the *pholas*, and the *teredo*, there appears no essential difference; it consists always of two ganglia, one on the mouth, representing the brain, and another towards the opposite part. These two ganglia are united by two long nervous cords, which take the place of the usual collar, but which occupy a much greater space—as the foot, when it exists, and the stomach and liver, always pass in the interval between them. All the nerves arise from the two ganglia.

A. *In the Anodontites, or Fresh-water Muscles, in Cockles, in the Venus, the Mactra, and the Mya.*

In these, and in general all the bivalves, which have two cylindrical muscles, one at each extremity of their valves, for the purpose of bringing them together; the mouth is placed near one of those muscles, and the anus near the other. The foot appears about the middle of the shell; and the tubes for the excrements and respiration, when they exist, go out at the end of the shell, opposite to that in which the mouth is situated. The brain is placed upon the anterior edge of the mouth; it is oblong transversely; it sends off two cords anteriorly, which go to the adjacent muscles, and turning towards each side, penetrate the lobes of the
cloak.

cloak, passing through the whole extent of their edge. The brain furnishes also, on each side, some filaments to the membranous tentacula, which surround the mouth, and detaches, from its posterior edge, the two cords, analogous to the medullary collar in other invertebral animals. These cords proceed, each on its side, under the muscular stratum, which envelopes the liver and the other viscera, and which becomes thicker, as it is continued to form the foot, which is frequently constructed for spinning.

When arrived at the posterior muscle which closes the valves, these cords approach each other, and enlarge as they unite, to form the second ganglion. This ganglion has the form of two lobes. It is at least as large as the brain-ganglion, and always much more easily distinguished. It detaches two principal nerves on each side, and the four together represent a kind of St. Andrew's cross. The two anterior nerves, as they ascend, proceed a little towards the side of the mouth, and, after having described an arch, penetrate into the branchiæ. The other two pass on the posterior muscle, precisely in the same manner as those of the brain on the anterior. After detaching some filaments, they proceed into the cloak, the edge of which they follow, until they join those of the brain; they thus form a continued circle. We do not yet know

know the origin of the nerves of the viscera in these animals.

The testaceous acephala, in which the foot is protruded by an extremity of the shell, that always remains open, and the tubes, by the opposite extremities, that is to say, in *razor-fish* and *pid docks*, the mouth, and consequently the brain, is always near one extremity. The nerves, which proceed from the brain, take therefore a longer course before they diverge to join the cloak. The cords of the collar, however, have a much shorter distance to pass before they unite. There is a considerable space, particularly in the razor-fish, between the mass of viscera situated in the base of the foot, and the posterior muscle. The second ganglion is situated in the middle of this space, between the branchiæ of each side: it is round, and much more distinct than in the other species; the nerves it produces are however exactly similar.

In the *oyster*, which has no muscle at the anterior part, the brain and mouth are situated under the kind of hood which the cloak forms towards the hinge. The nerves go directly into the cloak itself. The ganglion is situated on the anterior surface of the single muscle, immediately behind the mass of viscera. The nerves it produces are the same as in the preceding genera.

B. *In the Ascidia.*

These small marine animals are enveloped in an immoveable coriaceous, or gelatinous case, which has two apertures ; one for the expulsion of the excrements, the other for the admission of the water to the branchiæ. The branchiæ are in the form of a large sac, and are enclosed, as well as the other viscera, in another membranous bag, of the same form as the external case, but smaller, and completely adhering to that case at the two apertures only. The inferior ganglion is situated on this membranous sac : its position is between the two apertures, but nearest that which corresponds to the anus ; it produces four principal nerves ; two ascend towards the superior, or respiring aperture ; the other two descend towards that of the excrements. There are smaller nerves which are dispersed throughout all the membranous sac. We have not yet discovered those produced by the brain, nor the brain itself, which is doubtless situated as usual on the mouth. The mouth is in the bottom of the branchial sac.

C. *In the Tritons of Linnæus which inhabit the Anatififerous and Balanite Shells. (Lepas Lin.)*

These animals approach, perhaps, nearer to the Crustacea, and particularly to the monoculi,
than

than to the Mollusca. Their nervous system is of a sort of middle kind between that of the Mollusca and that of the Crustacea and Insects.

The brain is placed across the mouth, which is itself situated in the part of the body corresponding to the ligament, and at the bottom of the shell. It produces four nerves to the muscles situated in that place, and to the stomach, and two others which embrace the œsophagus, and proceed into that elongated portion of the body which bears the numerous articulated and ciliated horny tentacula which the animal protrudes from its shell. These two filaments approach and form a ganglion, and then proceed close to each other among these tentacula, furnishing a corresponding pair of nerves for each pair of tentacula, but there are no apparent ganglia at the origin of these nerves.

From what we have stated in this and the two preceding articles, it results,

That the nervous system of Mollusca consists in a brain placed on the œsophagus, and in a variable number of a ganglia, sometimes approximated to the brain, and sometimes dispersed in the different cavities, or placed under the muscular envelopes of the body; that the ganglia are always connected to the brain and to each other by nervous cords, which establish a general communication between these different medullary masses; that the nerves all arise either from the brain or the ganglia; and finally,
that

that there is no part which can be compared to the medulla oblongata and the medulla spinalis.

ARTICLE IV.

Brain and Nerves of the Crustacea.

THE Crustacea, which, in their organs of motion, very much resemble insects, though those of circulation and respiration are exceedingly different, have also a nervous system similar to that class, at least in the essential parts.

In the *long-tailed cray-fish*, the middle part of the system is a knotted cord, which extends from one extremity of the body to the other. The *short-tailed* kind, commonly called *crabs*, have a medullary circle in the middle of the abdomen, from whence the nerves of the body proceed like radii.

In these animals the brain is placed at the anterior extremity of the snout, and consequently at a considerable distance from the mouth, which opens under the corselet. On this account the cords which make the collar of the œsophagus are more elongated than in other animals.

A. *Brain of the common Cray-Fish, (Astacus Fluviatilis, Fab.)*

The brain of this animal forms a mass which is broader than long, and distinctly divided on the superior surface into four round lobes. Each of the middle lobes produces an optic nerve from its fore part. This nerve proceeds directly into the moveable tubercle which sustains the eye, and is there dilated and divided into a multitude of filaments, which form a pencil, and unite to all the small tubercles of the eye.

Four other nerves arise from the inferior surface of the brain; these proceed to the four antennæ, and detach some filaments to the neighbouring parts. The cords which form the collar, arise from the posterior part of the brain. About the middle of its length each detaches a large nerve which extends to the mandibles and their muscles. These cords unite under the stomach in an oblong ganglion, which furnishes nerves to the different pairs of jaws. On leaving this part the two cords remain near each other throughout the whole length of the corselet, where they form five successive ganglia, placed between the articulations of the five pairs of feet: each foot receives a nerve from its corresponding ganglion, which penetrates to the extremity of the foot: the nerve of the forceps is the largest. The medullary cords extend into the tail, where they

they are so intimately united that it is not possible to distinguish them. They form six ganglia, the five first of which produce each two pairs of nerves; the last produces four, which are distributed as radii to the scaly fins that terminate the tail.

The *hermit crab*, (*Pagurus*, Fabr.) the tail of which is not covered by articulated scales, appears to have much fewer ganglia than the *crayfish*. We have observed only five.

In the *squlla* Fabr. there are ten ganglia without reckoning the brain: that at the union of the two cords which form the collar, transmits nerves to the two forceps, and to the three pair of feet which immediately succeed them, and which in these animals are ranged almost on the same transverse line; this ganglion is therefore the longest of all. Each of the three following pairs has a particular ganglion. There are afterwards six ganglia in the length of the tail, which distribute their filaments to the thick muscles of that part. The brain produces immediately four trunks on each side, viz. the optic, those of the two antennæ, and the cord which forms the collar. As the antennæ are placed more posteriorly than the brain, their nerves are directed backward.

3. *In the Common Crab (Cancer Mænas, Lin.)*

The brain of the crab resembles that of the
Y 2 cray-

cray-fish in its form and situation; it also furnishes analogous nerves, but they are directed more towards the sides in consequence of the position of the eyes and the antennæ. The medullary cords which form the collar, detach each a nerve to the mandibles, but the cords are prolonged much farther backward than in the cray-fish before they unite. They join only in the middle of the thorax, at which place there is produced a medullary mass of an oval ring-like figure, which is eight times the size of the brain. The nerves which proceed to the different parts arise from the circumference of this ring. It furnishes six nerves on each side to the jaws and the five feet, and there is a single nerve which arises from the posterior part, and proceeds to the tail. This medullary ring may be said to represent the usual knotted cord, but if it has any ganglia they are not visible.

C. *In the Oniscus Asellus.*

The two cords which compose the middle part of the nervous system in this animal, do not perfectly join. We can distinguish them throughout the whole of their length. There are nine ganglia, exclusive of the brain; but the two first and the two last are so close together, that the number may be reduced to seven.

D. *In Monoculi.*

We know not the nervous system of the *molucca crab* (*limulus gigas*, Fab. *monoculus polyphemus*, Lin.) In the *monoculus apus* of Linnaeus, however, the indistinct nature of that system, joined to some other peculiarities of organization, would almost induce us to class the animal with the inarticulated worms. The brain is a small globule, nearly transparent, situated under the interval of the eyes. The medullary cord is double, and has an enlargement at each of the numerous articulations of the body; but the whole is so thin and transparent that the real nature of the cord can scarcely be ascertained.

ARTICLE V.

*Brain and Nerves of the Larvæ of Insects.*A. *Coleoptera.*1. *Larva of the Scarabæus nasicornis.*

WE shall give a particular description of the nerves of this larva, because their distribution is essentially different from that which takes place in the other coleoptera.

The brain is situated under the great scale which covers the head immediately above the origin of the œsophagus : It consists of two approximated lobes, which are very distinct at the front and back part. Four nerves arise from the anterior part, two on each side, which are lost in the cirri and parietes of the mouth.

From the lateral and somewhat posterior parts of the brain, there arises a pair of nerves, which, embracing the œsophagus, proceeds inferiorly to form the nervous cord we shall presently describe.

Another pair departs from the inferior surface of the brain, or that part which rests upon the œsophagus : these are first directed forward ; they afterwards turn inward, and proceed above the middle and superior part of the œsophagus, in order to approach each other. When they come in contact, they unite and form a small ganglion, which produces a single nerve ; this nerve continuing to proceed posteriorly, passes below the brain, and accompanies the œsophagus to the stomach. It there enlarges again into a ganglion, which furnishes some small nerves that are sent to the stomach, and one more considerable, which is continued along the intestinal canal, and sends off, at regular distances, lateral filaments, which are lost in the coats of this tube. This nerve is analogous to that which Lyonnet has described under the name of *recurrent*, in the caterpillar of the *coffas*.

The medulla spinalis, which, as we have shewn, is formed by the posterior pair of nerves of the brain, is very thick at its origin: it forms a large fusiform ganglion about 0,005 metre long, and half a millimeter broad. Four or five contractions appear on its anterior part, but they are so slight that they seem only transverse furrows. The posterior part of this ganglion is smooth.

From the lateral parts of this large ganglion, which extends very little beyond the third ring of the body, a great number of diverging nervous filaments are produced. Those which are nearest the head ascend a little; those which succeed them proceed almost transversely; and the last are directed more and more posteriorly: the length of each is in proportion to its distance from the anterior part of the ganglion. The two most posterior filaments are therefore the longest.

2. *Larva of the Stag Beetle (Lucanus cervus.)*

The nerves of this larva differ greatly from those of the preceding, although the perfect insects are so nearly allied in genera.

The brain consists of two contiguous and almost spherical lobes; these produce four nerves anteriorly for the antennæ and the parietes of the mouth: two inferiorly, which first proceed forward, then turn back, pass again under the brain, and form the nerve known under the

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name of *recurrent*. Lastly, two posteriorly, which form a collar round the œsophagus, and join underneath, to compose the nervous cord of the body.

This cord is formed of eight ganglia, which extend to the ninth ring of the body. The distances between these ganglia are very unequal; they are joined by very slender and closely approximated nervous filaments.

The first ganglion, from the head, is very large, and almost spherical; it is followed almost immediately by the second, which is one half less, and which is distinguished from it only by a kind of contraction; the first produces four pairs of nerves on each side; one ascends to the head; the other three diverge, and are lost in the muscles of the abdomen, and in those that move the head. The second ganglion, besides the two nerves that unite it to the third, produces two other nerves, which are also directed backward, and lost in the muscles of the fourth ring.

The third ganglion, and those that follow as far as the eighth, are similar to the second; with this difference, that they are much more distant from each other, and that they produce longer filaments, in proportion as they are situated more inferiorly. Lastly, the eighth and ninth ganglia are so close together, that they seem to form but one, with a slight contraction in the middle. This double ganglion produces three
pairs

pairs of nerves, which are much elongated, and extend to the parts near the anus.

3. *Larvæ of the Cerambyx, Hydrophilus, Carabus, and Staphylinus.*

The nerves of these larvæ being very similar, it will be sufficient to describe them in one genus only. We shall take for our example the larva of the *great diver* (*Hydrophilus piceus*.)

The brain in this animal is situated in the head, above the origin of the œsophagus; it is formed of two lobes, which lie very close together. From its anterior part it detaches some filaments to the palpi, the antennæ, and the parietes of the mouth. Its lateral parts produce two cords which surround the œsophagus, and which are the origin of the nervous cord situated inferiorly. It is probable that recurrent nerves also arise from this inferior part, but we have not yet been able to discover them.

The chief nervous cord is composed of ten ganglia, each of which produce three pairs of nerves that are lost in the muscles of the abdomen, and without any distinct appearance of their being distributed to the intestines. This induces us to believe that there is a recurrent nerve.

The first ganglion is very large; it is prolonged posteriorly into two nervous filaments, considerably removed from each other; the second is almost similar; but the third is very
near

near the fourth, which produces only a single filament posteriorly. All the others, as far as the tenth, present no particularity. The last is divided by a sensible contraction; from the first portion a single filament arises on each side, and from the second, three pairs of nerves are detached: thus four pairs of nerves arise from this ganglion. The fourth pair is directed to the rudiments of the parts of generation, which are very distinct in these larvæ in the last period of their growth.

4. *Larva of the Water-beetle (Dytiscus Marginalis.)*

The brain of this larva is spherical, and consists of a single lobe, situated in the head above the origin of the œsophagus; its anterior part produces some filaments for the mouth; and its lateral parts the two optic nerves: the latter are composed of two parts, which are very distinct as to form. The first portion, or that which is next the brain, is of an oval figure, pointed at the extremity which joins the brain: the other extremity is rounded, and produces a slender nerve, which goes directly to the eye. It is nearly of the same thickness throughout the whole of its extent; but it is enlarged at its free extremity into a bulb, from which the nervous filaments of the eye arise.

The two cords which embrace the œsophagus are short and thick; they arise from the inferior
surface

surface of the brain, and immediately unite below the œsophagus, in a large square-shaped ganglion, which produces anteriorly the nerves of the mandibles, and posteriorly two cords, which pass from the head into the corselet.

There is a greater distance between this first ganglion of the nervous medulla and the second, than between any of the others. It is more than double that which exists between the two next ganglia. The second ganglion is round; it produces two pair of nerves laterally; the anterior for the muscles which act upon the head, the posterior for those which move the anterior feet. There are two cords posteriorly, which are directed into the breast.

The third ganglion is similar in every respect to the second; it furnishes nerves to the intermediate pair of feet.

The fourth ganglion is also produced by the two cords which come from the preceding; it is situated on the union of the abdomen with the breast; it is more broad than long. Laterally it produces two pair of nerves, which run transversely parallel, and are lost in the muscles.

The other eight ganglia are placed close behind each other, and the space between them is so small, that we can scarcely perceive the two nervous filaments which unite them; they also decrease in thickness, without diminishing in breadth, as they extend posteriorly. They all furnish laterally a pair of very long nerves,
which

which float in the abdomen, and for the most part terminate in the muscles that move the wings. One pair, however, proceeds to the rudiments of the parts of generation.

B. *Orthoptera and Hemiptera.*

The nerves of the larvæ of orthoptera and hemiptera present no sensible difference from those we observe in the perfect insects. It will be sufficient therefore to describe the nerves of the latter.

C. *Hymenoptera.*

In the larva of the *saw-fly* (*Tenthredo*, Lin.) which has a large head furnished with eyes, the brain is very broad and short; it seems to form four bulbs of equal magnitude, and nearly spherical; the two external serve as the base of the optic nerves, which are slender, and which enlarge a little at their other extremity.

The first ganglion is produced by two very small nerves, which arise from the inferior surface of the brain, and which, after having embraced the œsophagus, unite under the first ring of the body; it furnishes filaments to the muscles of the feet, and terminates posteriorly in two other nerves, which, at the distance of one line, produce a second ganglion, and so on in succession: the nervous cord is in this manner formed of eleven ganglia, without reckoning the
the

the brain; the farther the ganglia are removed from the head, the more they diminish in thickness; they are all nearly of a round form.

D. *Neuroptera*.

In the larva of the *lion-ant* (*Myrmeleon Formicarius*) the nervous system has some relation to that of the larva of the dipterous insects, which we shall afterwards describe.

There is a brain situated in the head; it produces nerves analogous to those we have already pointed out in the other larvæ.

The nervous medulla consists, in the first place, of two ganglia, which are composed of two lobes, situated close together; these two first ganglia are separate from the others, and contained in the part corresponding to the feet, or in the thorax.

The remainder of the nervous medulla is enclosed in the abdomen; it consists of eight ganglia, placed in an exceedingly close series, and each formed of two lobes; the first is nearly double the size of the other seven. This succession of ganglia appears to the eye like the extremity of the tail of a rattle-snake; the last is round; the others are more broad than long. All these ganglia furnish nerves to the muscles. It is probable that this disposition and approximation of the ganglia have a relation to the changes which take place in the insect at the moment

moment of its metamorphosis, as its abdomen then occupies six times the space it does in the larva state.

In those larva of Neuroptera, which are nearly as long as the perfect insect, we find that the ganglia are separated in the usual manner.

The larva of the *ephemera* has eleven ganglia, without including the brain, which furnishes two large optic nerves. There are three ganglia in the thorax, and seven in the abdomen: the first six, reckoning all the ganglia, furnish more nerves than the five last.

The larvæ of the *dragon-flies* have a small two-lobed brain, which produces optic nerves, larger or smaller according to the species. The genus *aëfna* has them the largest. The rest of the nervous system forms a series of ganglia of different sizes. In the *aëfna*, the corselet contains six, the two last of which are the largest of all. There are seven small and equal ganglia in the abdomen.

E. *Lepidoptera*.

The nervous system of *caterpillars* consists of a series of thirteen principal ganglia, which furnish filaments to all the other parts of the body.

The first of these thirteen ganglia is situated in the cavity of the head; it lies above the œsophagus, and supplies the place of the brain:
it

it appears formed superiorly by the union of two round tubercles. Inferiorly it is concave, and corresponds to the convexity of the œsophagus.

This ganglion communicates with the rest of the nervous cord by two thick filaments, which embrace the œsophagus, and which are united below it to the anterior and lateral part of the next ganglion ; it besides produces eight pairs of nerves.

The first partly unites with other filaments ; produces some for the œsophagus, and forms several remarkable ganglia below the upper lip. The largest and most posterior, which Lyonnet has named the *first frontal ganglion*, is prolonged posteriorly into a thick *recurrent nerve*, which is continued the whole length of the body, near the back ; this recurrent nerve furnishes filaments to the œsophagus and its muscles ; it penetrates into the dorsal vessel, and it afterwards re-appears, and glides along the œsophagus as far as the stomach. This nerve produces, at certain distances, very solid filaments, which keep the œsophagus attached to the skin of the back.

Besides the recurrent nerve we have just noticed, several filaments are furnished by the posterior frontal ganglion to the muscles of the œsophagus, and two to the *second frontal ganglion* : the latter also detaches several filaments to the œsophagus, and, in particular, a very
remark-

remarkable one, which, by a sudden enlargement, constitutes the *third frontal ganglion*. This ganglion likewise affords several filaments to the œsophagus.

The second pair of the brain appears chiefly intended for the antennæ, though it furnishes several filaments to the neighbouring parts.

The third pair terminates particularly in the antennæ, and the muscles which move them.

The fourth pair is proper to the eye of each side; it accompanies the air tube which goes to that part, and is divided into six branches, that penetrate into the six eyes, which, by their union, form that of the caterpillar.

The fifth is directed a little backward, where it divides into two branches; one posterior, for the adductor muscles of the jaw; the other anterior, which is lost in the membranes that cover the frontal scales.

The sixth and seventh pair unite to form a ganglion, from which several filaments are detached to the œsophagus and its muscles.

Finally, the last pair of the brain is entirely lost on an air tube.

But besides these nerves produced by the first nervous ganglion, several others are detached from it, which we shall briefly notice. In the first place, we observe, that it furnishes several filaments to the dorsal canal: it afterwards gives origin to a pretty long filament, which terminates on the air vessels, between the second and
third

third ganglion. Lastly, it produces a nervous ring, which embraces the œsophagus inferiorly, like a girth, and supplies it with several filaments.

The second ganglion is intimately united with the third, and is distinguished from it only by a contraction. The nerves which proceed from the anterior part appear to be produced by the second ganglion, and those which arise from the posterior part, seem to belong to the third.

Besides the two filaments which form the collar round the œsophagus, and which unite the first to the second ganglion, the latter has four pairs of very distinct nerves.

The most anterior pair is sent forward to the mouth, but in its course it divides into two branches: one terminates in the tongue and the adjacent parts; the other branch proceeds to the lateral parts, where it sub-divides, to supply the mandible, the jaw, and upper lip, communicating, at the same time, with the first ganglion, and with the second frontal.

The second pair proceeds to the jaw, but detaches a number of filaments to the muscles of the neighbouring parts.

The third pair is destined for the spinning apparatus; in its course it gives filaments to the silk vessels and muscles of the head.

The fourth pair arises near the contraction, which indicates the union of the two ganglia, between the head and the first ring; it is lost in

the fat, in the skin of the neck, and in the muscles inserted into the head.

The third ganglion, which, as we have observed, is united to the second, produces only three pairs of nerves: the posterior is merely the continuation of the nervous trunk of the other two pairs; the anterior is entirely lost in the muscles and the skin; the intermediate pair supplies that part also; but it is distributed chiefly to the muscles, which move the articulations of the leg.

We have already stated, that each ganglion communicates with that which precedes, and that which follows it, by two filaments, that are distinct from their origin, and are the bifurcation of a single trunk. The middle of this bifurcation, from the third to the eleventh ganglion, produces a small nerve, which Lyonnet has named the *spinal frænum*: this single nerve is situated in the middle line; it presently divides into two branches, which follow the divisions of the air tubes, and penetrate with some of them into the longitudinal vessel.

The fourth and fifth ganglia produce the same number of nerves, the distribution of which is also nearly similar; their anterior pair proceeds to the muscles, and to the skin of the rings to which it corresponds; the intermediate pair furnishes, more particularly, filaments to the muscles of the leg.

The sixth ganglion, which corresponds to
the

the fourth ring of the body, also furnishes two pair of nerves, which are lost in the muscles and the skin.

The nerves of the five following ganglia are distributed nearly in the same manner.

The twelfth ganglion, and the thirteenth, which is the termination of the nervous cord, are very close to each other, though distinct. The distribution of the nerves, produced by the first, present nothing remarkable. Those furnished by the second are very long, being sent to the last rings, in the skin and muscles of which the first pair is partly lost. The second pair is only sub-divided when it has reached the first ring; it there produces a plexus, from which a number of filaments are detached to the great intestine. The trunk appears to end on the parietes of the rectum towards the anus.

F. *Diptera*.

The nerves of the larva of the *stratomyis* have some resemblance to those of the larva of the *scarabæus nasicornis*.

The brain is formed of two lobes, placed close together, and almost spherical; it is situated above the œsophagus, on a level with the second ring of the body. A number of small nervous filaments arise from its anterior part, and are distributed to the parietes of the mouth, to the mandibles, and to all the adjacent parts.

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These nerves are very distinct, particularly those which are removed from the middle line.

The posterior part of these two lobes sends off two thick branches, which embrace the œsophagus, and form the origin of the nervous medulla.

This nervous cord is very short, and its diameter is one half less than that of the brain; it consists of eleven ganglia placed very near each other, each of which produces one pair of nerves.

These nerves proceed directly backward. Swammerdam has erroneously represented this cord as twisted, like the tail of a scorpion, and producing nerves on the left side only. It is true, that those which arise from the right side are parallel to the cord, while those of the left side remove farther from it. The ganglia, thus approximated, are eleven in number, and in a straight direction; they produce long nerves, which are lost in the muscles.

The nerves of the *cheese-worm* (*musca putris* Lin.) are distributed in a very curious manner.

The brain is situated immediately above the origin of the œsophagus, behind the head; it is very large in proportion to the rest of the body; it is rounded posteriorly, and notched anteriorly, as if it were formed of two lobes.

A pair of nerves arise from the anterior part of the brain, proceed forward, and are distributed to the mouth, and even to the parietes of
that

that cavity. It should be remarked, that these nerves experience a very conspicuous enlargement previously to their distribution.

Posteriorly the brain presents an aperture, which affords a passage for the œsophagus : the nervous part, situated on its sides, may be regarded as the cords which produce the medulla, and all below the œsophagus as the medulla itself.

Two pairs of nerves arise from the origin of the nervous medulla ; these are directed forward, and principally distributed to the viscera, and to some of the muscles of the anterior rings.

The third pair of nerves which this medulla produces, is the most remarkable ; it comes from the part which nearly corresponds to the third ganglion ; I say nearly, because in this insect the ganglia are so close to one another, that the medulla seems to form only one piece on the surface, of which we merely perceive twelve transverse wrinkles, which indicate the number of ganglia. This third pair extends almost transversely. At a certain distance from its separation it swells into a ganglion, and then divides into several filaments ; these are the ganglia which Swammerdam supposes are intended for the muscles of the wings, when they shall exist in the perfect insect.

Another pair of nerves, which go to the muscles of the body, arise from each of the

other contractions ; but they require no particular remark.

ARTICLE VI.

Brain and Nerves of Perfect Insects.

A. Coleoptera.

1. In the Stag-beetle (Lucanus Cereus.)

WE find in this insect, as in its larva, a brain composed of two approximated spherical lobes, situated above the œsophagus ; its anterior part produces two pair of nerves, which terminate in the palpi, and other parts of the mouth. There is probably a recurrent nerve, but our researches have not yet discovered it.

There are two ganglia on the lateral parts of the brain, which are almost as large as each of the lobes. In their form they resemble a pear, and rest upon the brain by their base ; they are prolonged transversely into a large nerve on each side, chiefly intended for the eye. Before the nerve arrives at that part, we observe it detach a slender filament, which enters into the great mandible ; then, more externally, another filament which enters into the cavity of the antennæ ;

tennæ; lastly, the nerve itself having reached the eye, swells again into a bulb, and produces a number of nerves, which we shall describe when we treat of the Organ of Vision.

Posteriorly the brain produces two very long and slender nerves, which accompany the œsophagus to the point where the head unites to the thorax, immediately above the articular condyle. The two nerves situated above the œsophagus, then produce a ganglion of a long oval form, from which several nervous filaments are detached to the muscles that move the mandibles, and those that act on the head. This ganglion terminates posteriorly in two parallel nerves, which proceed to the middle of the thorax, above the origin of the two pair of feet, and there form a second ganglion of an hexagonal figure; this ganglion furnishes filaments to the muscles of the feet, and likewise terminates posteriorly in two nerves, which extend above the union of the corselet, with the pectus; they there unite and form a third ganglion, which is crescent-shaped, with the convexity posterior: two other nerves proceed from this convexity, which almost immediately produce another ganglion of the same form, but smaller. This ganglion gives origin to five nerves: two lateral, destined to the muscles of the intermediate feet, into the coxæ of which we observe them enter: posteriorly two, which are slender, and distributed to the muscles of the hind feet and

the wings. The fifth is situated in the middle line; it is also thicker: it swells almost immediately into an oval shaped ganglion, which is divided posteriorly into two exceedingly slender filaments. These filaments, which pass into the abdomen, form a kind of bridge in the breast, in which they occupy the middle line, and leave between them the muscles of the feet and wings of either side.

2. *In the Scarabæus nasicornis.*

With respect to the nerves, this insect differs in the perfect state from the description we have given of its larva.

The optic nerves, which are very distinct and large, proceed to the eye, into which we observe them enter by a multitude of filaments when we make a horizontal section of that organ.

The nervous cord presents a very conspicuous difference. In the larva there is only a single ganglion; but the perfect insect has several, which are very distinct.

The first is situated above the condyle; it proceeds from the two posterior filaments of the brain, and is distributed to the muscles which move the head on the corselet. Its posterior part produces two filaments, which pass into the breast, where they unite towards the middle part, and form a triangular ganglion; from the sides of which three pairs of nerves arise, and are distributed to the muscles. Its posterior angle
detaches

detaches two parallel nerves, which proceed into the breast, where they form a third and a fourth ganglion, situated very near each other, and apparently divided into two lobes by a longitudinal furrow. All the other nerves of the body depart from those two ganglia by an irradiation, precisely in the same manner as in the larva.

3. *In the Water Beetles (Dytiscus) and the Ground Beetles (Carabus.)*

The nervous system is entirely similar in these insects. The brain is formed of two large hemispheres, separated from each other by a longitudinal furrow. The anterior part produces the nerves of the mouth, and the lateral parts those of the eyes and the antennæ. The nerves of the eyes are short, and differ greatly from those of the stag beetles; they are of a pyramidal form: their base corresponds to the eye, and their apex to the brain. We have not observed any recurrent nerves.

The two filaments which produce the nervous cord depart from the brain, not posteriorly, but inferiorly, on the side of the optic nerves; they are very short, as they pass immediately under the œsophagus. They furnish some filaments to the muscles and the œsophagus.

The first ganglion they form lies under a kind of bridge, formed of horny substance, which is situated in the middle of the head, and which affords a point of attachment to the muscles of the

the jaws; it is of an elongated and quadrangular figure, and occupies almost the whole space that corresponds to the condyle above which it is placed.

It is terminated posteriorly by two filaments which proceed in a parallel direction, and form a second ganglion in the middle part of the corselet. This ganglion furnishes nerves to the muscles of the anterior feet. We observe them enter into the cavity of the coxæ.

The third ganglion appears bilobed, or formed of two oval bulbs, the union of which is marked by a longitudinal furrow. This ganglion is situated longitudinally above the anterior inferior edge of the breast. It sends filaments to the muscles of the intermediate feet.

The fourth ganglion is very near the preceding; it is of a roundish form, and is distributed to the muscles of the posterior feet and the wings.

The space between the fifth and the sixth ganglion is very small: their form is round; and they furnish filaments to the muscles that move the abdomen on the breast.

The remainder of the medullary cord is formed by a series of five ganglia, situated so close to one another, that they appear to the naked eye to form only one; but with a glass they may be observed very distinctly. We even perceive the two filaments produced by each to form the succeeding ganglion. The fifth presents a transverse

verse furrow, which seems to indicate the union of two ganglia. The end of the medulla appears to float in the abdominal cavity, but above the intestines.

4. *In the Great Diver (Hydrophilus piceus*
Lin.)

The brain of this insect, which is situated in the head, and above the origin of the œsophagus, consists of two spherical bulbs closely united. The lateral parts give origin to the optic nerves which proceed towards the eyes without changing their diameter, but which terminate there by a triangular bulb that produces a vast number of filaments externally.

The anterior part of the brain detaches some filaments intended for the parietes of the mouth. We also remark, at the same place, a small spherical ganglion, which appears to belong to the *recurrent* nerve that accompanies the œsophagus.

Two filaments, which should produce the medullary cord, arise inferiorly: they embrace the œsophagus at their separation, unite immediately below it, and again, in the cavity of the head, to form a small ganglion, which furnishes nerves for the muscles of the mandibles and the palpi.

Two nervous cords are detached from the posterior part of this first ganglion. Almost immediately after their origin, they pass under
a horny

a horny arch, which is produced by the internal surface of the *ganache*. We observe that they re-appear posteriorly, and proceed into the corselet.

They form a second ganglion exactly in the middle of the corselet; its figure is quadrangular. The anterior and posterior angles produce the nerves of the medulla, and the lateral those intended for the muscles of the anterior feet.

The interval included between the second and third ganglion of the medulla is very great. The third ganglion corresponds to the insertion of the intermediate feet: it is large, and of a round form; it furnishes nerves to the wings, and to the intermediate pair of feet. Posteriorly it produces two cords, which, at the distance of about half a line, swell and form a fourth ganglion, almost as large as the preceding. This ganglion detaches, from its inferior part, a number of filaments for the muscles of the posterior feet, which are specially appropriated to swimming. Two other very short cords produced by the posterior part of this ganglion swell into a fifth, which is one half less than the former, and which furnishes a single cord posteriorly. This cord passes into a kind of longitudinal groove, formed above the horny appendix, that furnishes attachments to the muscles of the coxæ, and which we have described in the first volume.

A sixth ganglion is situated at the posterior and wide part of this appendix: at a certain distance,

distance, and exactly above the union of the abdomen with the breast, a seventh appears. These two ganglia produce only one pair of nerves, which are distributed to the muscles.

There are only two ganglia in the abdomen; one corresponds to the middle part of the second ring; the other, which is the last and ninth, is situated above the union of the second segment with the third. The last ganglion but one is in every respect similar to the two preceding; but the ninth is one half larger, and produces posteriorly four pair of nerves, which are distributed on both sides to the parts of generation.

B. *Orthoptera*.

In the Cockroach (Blatta Americana.)

The brain of this insect is composed of two lobes, separated by a very distinct notch anteriorly. The optic nerves arise on the sides, and its anterior part detaches some filaments to the parietes of the mouth, and to the instruments of manducation.

The nervous cords which form the medulla arise from its inferior surface. They proceed directly downward, and closely embrace the œsophagus. They afterwards proceed in a parallel direction, but very distinct from each other, towards the corselet. When they reach its middle, they form a very large ganglion, which produces

duces three pairs of nerves laterally, and one posteriorly. The first lateral nerves ascend obliquely towards the head, and furnish filaments to the muscles that move it on the thorax, and which act on the antennæ and the parts of the mouth. The others are distributed to the muscles of the first pair of feet.

The posterior nerves proceed in a parallel direction backward. At the middle of the pectus they produce a still more considerable ganglion than the second, which furnishes laterally nerves to the intermediate and posterior feet, as well as to the muscles of the wings. It also sends off two cords posteriorly, which, by their union at the junction of the abdomen and the breast, form a fourth ganglion, situated on a projecting horny substance to which the muscles of the coxæ are attached.

After this fourth ganglion there is only a single nerve, which has, at certain spaces, small enlargements. Five of these swellings may be counted. Each produces a pair of nerves for the muscles of the rings of the abdomen: the fifth is the largest, and furnishes besides two nerves which ramify in the parts near the anus.

In the Great Green Grasshopper (Gryllus Viridissimus, Lin.)

The brain is situated in the head above the œsophagus: it consists of two lobes, which have the form of pears, united at their base, and prolonged

longed at the other extremity into an optic nerve for the eye of each side.

The anterior part also produces two nerves of a pyramidal form, the base of which rests upon the brain. Some filaments arise from the apex of the pyramid, which are lost in the mandible, the jaw and its *galea*, as well as in the upper lip.

Between these two anterior nerves we observe a small ganglion, which is produced by the union of the two filaments of the inferior surface of the brain. This is the recurrent nerve which follows the intestinal canal.

Posteriorly, and a little inferiorly, we observe the origin of the two cords which form the nervous medulla. They embrace the œsophagus, below which they are immediately directed, and form a ganglion.

This first ganglion is protected and covered by a kind of horny bridge of a reddish colour. It furnishes nerves to the muscles of the mouth, and to those of the head within which it is inclosed. Posteriorly it produces two long nervous cords, which penetrate into the corselet.

These two cords unite about the middle of the thorax before the appendix, which gives attachment to the muscles of the coxæ and the anterior pair of feet. At this union they form a large bilobed ganglion, of an irregular quadrangular figure, the sides of which produce several filaments for the muscles of the anterior feet.

The

The posterior part of this second ganglion furnishes two filaments, which penetrate into the breast. The solid appendices of the coxæ, which afford insertions for the muscles, pass between these two filaments. They form a third ganglion, which corresponds to the middle space included between the two intermediate feet. This ganglion sends nerves to the muscles of the wings and the feet.

The fourth ganglion is also contained in the breast. It is situated before and between the posterior pair of feet. It is produced by two nervous cords from the preceding ganglion; and furnishes two posteriorly, which are so close to each other that they appear to the naked eye to make only one cord. This nerve is received and contained in a kind of groove formed above the triangular piece, which affords an attachment for the muscles of the feet.

The other ganglia, which are all situated in the abdomen, are six in number. They are, the last excepted, of the same size and form, placed at equal distances, and produced by two similar and closely approximated cords. Each furnishes two pair of nerves for the muscles of the abdominal rings.

The last ganglion of the medulla is one half larger than the five preceding. It is situated below the parts of generation, to which it is distributed by four pair of filaments.

In the Mole-cricket (Acheta gryllo-talpa.)

The brain of this insect is also composed of two rounded lobes, which are particularly distinct at the posterior part.

We can clearly perceive the origin of the nerves of the palpi, of the antennæ, of the smooth eyes, and the eyes properly so called.

In general the nerves of the principal medulla are similar to those we have described in the cockroach. The two first ganglia are produced by two nerves. The first, which is in the corselet, supplies the muscles of the head, breast and anterior feet. The second, which is larger, and in the breast, gives filaments to the muscles of the wings, and the intermediate and posterior feet. It also sends two nerves posteriorly, which produce the abdominal ganglion. The cord then becomes single and flat, like a ribband, and contains only four ganglia, occurring at different distances. Each produces two pair of nerves, which are directed posteriorly, and distributed to the muscles. The first corresponds to the middle part of the first abdominal ring; the second to the third, the third to the fifth, and the last to the ninth.

This last ganglion is the most remarkable of all. It is of an oval shape, and produces, from the whole of its circumference, nerves which are distributed to the neighbouring parts. Two, which are longer than the others, diverge as

they proceed backward, and thus represent a bifurcation of the medullary cord. These branches furnish filaments to the parts of generation.

C. Hemiptera.

In the oval Water Scorpion (Nepa Cinerea, Lin.)

The nervous system of this insect consists of three ganglia.

The first, which supplies the place of the brain, is situated in the head. It is formed of two approximated lobes. These lobes are pyriform, and touch each other at their base. Their summits are directed obliquely forward towards the eyes, in which they terminate, and thus answer to the optic nerves by their anterior extremity. The middle and anterior part of these lobes also produce some filaments for the parts of the mouth.

Posteriorly, the brain detaches two cords which embrace the œsophagus as they pass below it. They unite at the origin of the breast in a tetragonal ganglion; each of the angles of which produces or receives several nerves. The anterior receives the two cords which come from the brain; the posterior, the two which are the continuation of the medullary cord.

Each lateral angle produces a fasciculus, composed of four nerves, which are directed to the muscles of the breast and anterior feet. We observe

observe one of them enter into the cavity of the coxa.

The two nerves produced by the posterior angle of the second ganglion proceed in a parallel direction backward. Having arrived in the breast above the horny appendix, to which the muscles of the coxæ of the intermediate and posterior feet are attached, they swell into a large round ganglion, considerably more voluminous than the brain. A vast number of nerves are detached from the edges of this ganglion, like solar rays.

The two most remarkable filaments are exceedingly long and slender. They extend from the breast nearly as far as the anus: we have observed them to terminate by three minute branches in the parts of generation of the male, furnishing, at the same time, some filaments to the adjacent parts.

All the other filaments, which proceed from this third and last ganglion, are destined to the muscles. We can very plainly distinguish those that belong to the middle and intermediate feet, as they are somewhat larger than the others.

D. *Lepidoptera*.

In the Zig-Zag Moth (Phalæna Dispar, Lin.)

The brain in this species is almost spherical. We, however, perceive a longitudinal furrow on the middle line. Its anterior part produces

some exceedingly slender nerves. There are two large optic nerves on the sides, which proceed into the concavity of the eye, where they terminate by a bulb, which produces a great number of filaments.

The œsophagus passes immediately behind the brain, through a small triangular interval, the posterior sides of which are formed by the two cords of the medulla. These cords afterwards unite, and proceed in the form of a single trunk, on the middle part of which we perceive only a longitudinal furrow. Arrived in the corselet it forms a ganglion, the surface of which is reddish. This ganglion produces two nerves posteriorly, which leave between them an interval that affords a passage for the horny appendices to which the muscles of the coxæ are attached. The two cords again unite behind these appendices in the same cavity of the breast, and produce a much larger ganglion, the lateral parts of which furnish nerves to the muscles of the wings and feet. It is prolonged posteriorly into a single cord, which again enlarges when it arrives above the articulation of the breast with the abdomen into a third ganglion.

It should be remarked, that this large ganglion, which has the form of a heart, is the only one, besides the brain, of a completely white colour. All the others exhibit darker shades, and, when viewed by a glass, we observe in them reddish points more or less elongated and sinu-

ous,

ous, that resemble the blood vessels of injected glands.

The third ganglion is prolonged into a single cord, which produces a fourth ganglion above the first ring of the abdomen. The latter, as well as those that succeed it, detach on each side a long slender nerve which passes under the muscular fibres, precisely in the same manner as the threads of the woof pass through the warp in cloth. Their direction is completely transverse.

The fifth ganglion does not differ from the preceding. It is prolonged into a single cord, upon which we can still very distinctly perceive the longitudinal furrow. It is situated in the middle part of the third ring of the abdomen.

The sixth ganglion is, in every respect, similar to the preceding; it is placed in the middle of the fourth ring.

Finally, the seventh and last ganglion is much larger than those that precede it in the abdomen. It is of an oval form, and situated upon the lunula that terminates the fifth abdominal ring posteriorly. Besides the nerves intended for the muscles of the fifth ring, which are detached from this ganglion in two distinct parts, it produces four other pairs posteriorly. These nerves appear to be distributed to the parts of generation, and to the muscles of the last abdominal rings, which, in the female, are elongated like a tail to assist in laying eggs.

E. *Neuroptera*.

The insects with naked wings, that is to say, the Hymenoptera, Neuroptera, and Diptera, which have frequently very large eyes, have also the optic nerves of a proportional size. This is particularly observable in the *dragon flies*. Their brain is formed of two very small lobes; but their optic nerves are dilated into the form of two large plates, which have the figure of a kidney, and which is spread upon all the inner surface of the eye next the head. The remainder of their medullary cord is exceedingly slender, and furnished with twelve or thirteen small ganglia, the last of which is, as usual, connected with the parts of generation.

F. *Hymenoptera*.

The brain of the *bee* is small, and divided into four lobes. It produces immediately the nerves which are distributed to the different parts of the mouth, and the two large optic nerves which are dilated and applied behind each eye as in the *dragon flies*. There are afterwards seven ganglia, three of which are in the corselet, and four in the abdomen. The nerves of the last chiefly supply the parts of generation.

G. *Diptera*.

The *apiform fly* (*musca tenax*, Lin.) has a small brain, formed of two lobes, which are situated
very

very close together, but distinguished by a longitudinal furrow; the anterior part produces a large nerve, which is afterwards distributed to the antennæ and the proboscis.

The optic nerves are very thick, cylindrical, and equal in diameter to the length of the brain, on the lateral parts of which they rest; they terminate at their extremity in a very large bulb, which corresponds to the breadth of the eye.

The first ganglion of the medulla is produced by two cords, which come from the posterior part of the brain, and embrace the œsophagus as a collar; it is very slender, and situated in the breast; it furnishes a pair of filaments to the muscles of the anterior feet.

The second and the following ganglia, in all three in number, are united to each other merely by a single cord. The last ganglion is one half larger than that which precedes it. Posteriorly it produces eight or nine filaments, which are intended for the parts near the anus; the first of the three is situated in the breast, where it furnishes nerves for the muscles of the wings and the feet; the other two ganglia are in the abdomen; the last but one is placed above the union of the third ring with the fourth; and the last on the interior and inferior edge of the fifth ring.

In the *hornet-fly* (*asilus crabroniformis*) we also observe a single cord uniting the abdominal ganglia, which are six in number.

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The brain is similar to that of the *Syrphus*; but the bulbs, formed by the optic nerves, are still broader, in proportion to the extent of the eyes they have to invest,

H. *Gnathoptera*.

In the *great scolopendra* (*scolopendra morsitans*) the brain has a very singular form: it is, as usual, composed of two lobes, which are almost spherical; it produces laterally the optic nerves, which are very short, and may be observed to divide long before they reach the eye. The filaments are four in number; but two nerves arise anteriorly, which are so very thick, that they appear a part of the brain, to which they are equal in diameter. These nerves are particularly intended for the antennæ, into which we observe them enter, and in which they may be followed, on account of their magnitude.

The two cords which embrace the œsophagus proceed directly downward, and form a large ganglion at the union of the first ring with the head. The first ganglion produces two nerves posteriorly, and several towards the sides. A ganglion, precisely of the same shape, is placed above each of the articulations: thus there are, in all, twenty-four very distinct ganglia; the last of all is smallest, nearest the preceding, and seems to float in the abdomen; each detaches

three pair of nerves ; one which ascends towards the head, a second which runs transversely ; both these are distributed to the muscles of the abdomen : the third descends, and then proceeds backward and upward ; it furnishes filaments to the lateral muscles, and to those of the back.

ARTICLE VII.

Brain and Nerves of Worms.

SOME genera of worms present a very distinct nervous system, organized nearly like that of the Crustacea and insects. In others, however, that system becomes so obscure, that we can scarcely recognize its existence. Thus the class of worms which, in several of its genera, ranks above insects, with respect to the organs of circulation, is reduced almost to a level with the zoophytes, when considered with regard to the organs of sensation.

1. *In the Aphrodita Aculeata.*

The nervous system is very distinct in this animal. Immediately behind the tentacula, situated above the mouth, we observe a large nervous ganglion, which is the brain ; it has the form of a heart, the broadest and bilobed part of which is directed backward. The point-
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ed and anterior part produces two small filaments for the tentacula; and the lateral parts some other filaments, which are still more slender for the parietes of the mouth. This ganglion is situated immediately above the origin of the œsophagus.

The two cords which arise from the brain, and form the collar, are very long and delicate; they gradually increase in thickness, as they approach the point of their union. Each then produces a large filament, which we shall call the *recurrent* nerve; these nerves are very distinct; they are directed forward towards the part where the œsophagus, which is very short, joins the stomach; they may be easily followed by the naked eye to the lateral parts of that viscus, which is very long and muscular; before they reach the intestines that follow the stomach, they swell into a ganglion, which produces a great number of nervous fibrils:

The two nerves of the collar produce a very large ganglion at their union; it is bifurcated anteriorly, and situated immediately behind the mouth, and above the œsophagus; it is the anterior extremity of the chief nervous cord. We do not observe any filaments proceeding from it. To this first ganglion another succeeds, which is distinguished from it by only a small contraction; the latter produces two nervous filaments, which go forwards into the muscles of the abdomen. A series of ganglia, the spaces
 2 between

between which are considerably greater, afterwards succeed; each of these sends off six nerves, three on a side, which are lost in the muscles. These ganglia are twelve in number.

The nervous cord which succeeds, and which occupies the posterior third of the body, no longer exhibits any apparent enlargement; but pairs of nerves are still detached at certain spaces. Finally, this cord may be followed to the extremity of the body.

2. *In the Leeches,*

The nervous system is a longitudinal cord, composed of twenty-three ganglia.

The first is situated above the œsophagus; it is small and rounded; anteriorly it produces two slender filaments, which proceed above the disk of the mouth. The lateral parts furnish a thick pair of nerves, that form a collar round the œsophagus, as they proceed downward, and unite at the second ganglion.

This ganglion is of a triangular figure; it appears to be formed by the union of two tubercles. Two of these angles are anterior and lateral; they receive the nerves that proceed from the first ganglion. The other is posterior; it is prolonged into a nerve rather more than half a line long, which produces the third ganglion: the anterior part of the triangular ganglion which we describe, detaches two small
nerves

nerves that are lost on the œsophagus, around the mouth.

The nine succeeding ganglia are precisely of the same form, and produce each two pair of nerves; they differ only in the greater or less distance at which they are placed with respect to each other.

The third, as we have observed, is very near the second. The three following are at the distance of nearly a line and a half: but those which succeed, from the seventh to the twentieth, are at the distance of three or four lines: finally, the three last are very close together.

All these ganglia are situated longitudinally below the intestinal canal, to which they furnish, from their superior surface, a number of nervous filaments; they produce on each side two nerves, which pass into the longitudinal and transverse muscles, in the substance of which they are lost. These nerves run in opposite directions, so that they represent the figure of an X.

The coat of these nerves is black, and very solid: on this account, before the parts have been immersed in alcohol, the nerves appear like a system of vessels.

3. *In the Earth Worm,*

The nervous cord derives its origin from a ganglion situated above the œsophagus; this
ganglion

ganglion is formed of two close, but very distinct tubercles; it produces a pair of small nerves, which proceed to the parietes of the mouth, and two large cords, which embrace the œsophagus in the form of a collar; these unite to form the nervous cord, the origin of which, therefore, appears bifurcated. Three pair of small nerves are detached at this place; one from the cord itself, and the others from its lateral parts. They all proceed into the muscles of the mouth.

The nervous trunk is continued to the anus, along the inferior part of the intestine; its size is not sensibly diminished, and the contractions are not very remarkable: there are, therefore, no real ganglia.

A pair of nerves arises between each of the rings of the body; these nerves pass under the longitudinal muscles, and disappear between them and the skin.

When the nervous cord reaches the anus, it terminates by forming a plexus, which is lost on the parietes of that aperture.

4. *In the Gordius Argillaceus.*

There is only a single nervous cord in this animal, similar to that of the earth worm, but its contractions are still less apparent.

5. *In the Nereis and Terebella.*

In these animals we find, within the skin of
the

the belly, a longitudinal cord, which may be regarded as nervous: it has as many contractions as there are rings in the body. We have observed no nervous filament proceeding from this cord.

6. *In the Sea Worm, (Lumbricus Marinus Lin.)*

Which, by its external characters, approaches nearer to the nereis than the lumbricus. The nervous system is the same as in the nereides, but the cord gradually increases in thickness towards the middle of the body, where it is much more distinct.

7. *In the Ascaris Lumbricoides of Man and the Horse.*

This animal appears to have two nervous cords; they are observable throughout the whole length of the body, on the lateral parts of the abdomen.

They unite above the œsophagus exactly at its origin on the mouth; they are very slender, and produce no remarkable ganglion; they are smaller at their origin than towards their extremity, that is to say, towards the anus; but they are equal, and precisely similar to each other with respect to their different parts. We at first observe some small granular points, which enlarge in proportion as the nerve descends. When it has reached the middle of the body longitudinally, it forms square ganglia, at a
short

short distance from each other. Lastly, towards the termination, for the length of nearly six lines, the nerve becomes more and more slender, and ends in a very small filament, which unites with that of the other side.

The details into which we have entered in Articles IV. V. VI. and VII. of this Lecture, evidently demonstrate that there exists an analogy in the organization of the nervous system of the three classes of Crustacea, Insects, and Worms, no less striking than that which prevails in the external forms, in the disposition of the muscles, and in the singular division, into a series of rings or segments, which we observe in those animals. This analogy must prevent us from establishing, between these three classes, limits equally distinct with those that subsist between them and the Mollusca.

The uniform distribution of nearly equal ganglia upon a cord, extending throughout the whole length of the body, seems designed to furnish each segment with a brain peculiar to itself. Thus we are gradually conducted to that general diffusion of the medullary substance which takes place in zoophytes.

ARTICLE VIII.

Of Animals, in which no distinct Nervous System has yet been discovered.

WE do not include, in this division, the animals of the class of Worms, or the Mollusca, in which the minuteness or softness of the parts have not yet permitted us to trace the nervous system. Analogy will not allow us to doubt its existence, when the parts, which accompany it, uniformly exist. Thus the *flukes* (*fasciola*) having vessels, or liver, &c. must also be supposed to have nerves, though we have hitherto been unable to demonstrate them.

We even doubt not the existence of a nervous system in several intestinal worms, particularly those which have a cylindrical form, which we suppose to have a medulla nearly similar to that we have described in the large ascarides. It is found in the *gordius*. Why should it not exist in the *echinorhynchus*, *strongylus*, &c. &c.?

But there are animals in which analogy will not serve us, and to which we cannot attribute a nervous system, unless we distinctly observe it; these are some intestinal worms, very different in form from those we have mentioned, and the greater part of zoophytes.

We shall examine some of them.

1. *In the Sea Stars, (Asterias.)*

These animals have parts which may be regarded as very similar to nerves; but galvanic experiments ought to be made on living individuals, to prove completely their nature. Round the œsophagus we observe a girth of a soft whitish substance, which produces ten filaments, two to each of the branches, which form the body of the star; the two filaments belonging to each branch having arrived at the base of the osseous and articulated stalk, which serves for the principal support of the animal, unite to form a short cord, which extends directly from the one to the other; they afterwards both continue along the stalk to the extremity of the branch, diminishing always in thickness. At the place where they are united, each produces a fasciculus of filaments, which are distributed to the stomach, which, in these animals, is situated in the midst of the body, between the five branches.

The appearance of all these filaments is rather tendinous than nervous, and that circumstance has hitherto chiefly prevented us from forming a decided opinion of their nature.

2. *In the Holothuria.*

In the Holothuria, properly so called, among which we do not include either the *thalia*, or the *holothuria physalus* of Linnæus, we find

something similar to what we have described in the sea star, but the appearance of the cord is much more nervous, and this we consider a strong confirmation of our conjectures.

The parts of which we speak appear most distinctly in the species of holothuria, which have five longitudinal pairs of muscles, as the *priapus* and the *pentacta*. Between the two muscles which compose each pair, there is extended a white cord, slightly serpentine, and marked by transverse rings, precisely like common nerves. The five cords enlarge as they proceed towards the œsophagus, where it appears to us they unite to surround that canal.

3. *In the Sipunculus.*

These are more similar to the holothuria than to any other animal, though naturalists have hitherto placed them next the *Lumbricus*; they have only a single whitish cord, but it completely resembles those of the holothuria, and it proceeds in the same manner to embrace the œsophagus by its anterior extremity.

If these observations apply to real nerves, it will be necessary to separate the *echinodermata* from the other zoophytes, and establish them as a distinct class.

4. *In the Sea Urchins (Echinus Marinus.)*

We have not observed in these animals any thing that resembles nerves, but analogy will
 6 not

not permit us to separate them from the sea stars and holothuria. One species of this genus has been formerly very properly named the *coriaceous urchin*.

5. *In the Actinia and the Médusa.*

These animals form, in the class of zoophytes, a second family, which approaches pretty near to the preceding, and particularly to the genus *holothuria*, with respect to the arrangement of the parts; but it is impossible to perceive any thing in them like nerves.

6. *In the Polyps with Arms, (Hydra.)*

With respect to these and the neighbouring genera, which form, with the animals of the coral kind, the third and the most simple family of zoophyta, we have already had occasion several times to observe, that we discover in their bodies only a gelatinous and homogeneous pulp, which exhibits no apparent organization.

All these animals have however very distinct sensations: their sense of touch is very delicate; they not only perceive the motions which agitate the water in which they live, but they completely feel the degrees of heat and light. The expansion of the actiniæ corresponds precisely to the serenity of the atmosphere. The hydra perceives very distinctly the presence of light; it prefers it, and constantly turns towards it.

The microscopic animals appear to approach,

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in some measure, the nature of polyps, by their uniform and gelatinous structure. There are some, however, in which we observe a more complicated organization, and several kinds of internal viscera; but it will be readily imagined that we have not even thought of ascertaining whether they possess a nervous system.

LECTURE TWELFTH.

OF THE ORGAN OF SIGHT, OR OF THE EYE.

ARTICLE I.

General Idea of Vision.

By sight we distinguish the quantity, the colour, and the direction of the luminous rays which strike our eye. The difference of colours marks the limits of bodies in height and breadth; and the difference in the intensity of light, joined to the experience acquired by the sense of touch, enables us to recognize their cavities and inequalities. Lastly, from the direction of the rays, we form an opinion as to the line in which these bodies are situated.

We cannot obtain an immediate knowledge of real distance by sight only. We must in this case also avail ourselves of the experience acquired from the sense of feeling, and judge of the distance of objects, according to their known magnitude, compared with their apparent magnitude and degree of illumination.

As vision can only immediately afford ideas

of the quantity, quality, and motions of the rays of light, we are subject to make erroneous conclusions with respect to the objects from which these rays proceed. Thus rays reflected by a mirror, exhibit objects in a direction in which they do not exist. Rays refracted by glasses, change the apparent magnitude of bodies: when we know not the real size of an object, we are deceived with respect to its distance, and *vice versa*: a very luminous body appears nearest to us, when those which are between us and it are in the shade, &c. &c.

Rays do not excite any sensation, unless they fall upon a nervous membrane of the eye, called the *retina*; and they communicate no sensation conformable to the body which transmits them, unless they fall upon the retina precisely in the order in which they are detached from that body. To produce this effect it is necessary that all the rays which proceed from any one point of a body, should be collected in one point of the retina, and that all the points of union thus formed should be disposed in the same manner as in the body of which they form the image.

This necessity is a matter of simple experience; for it is easy to conceive that we are no better acquainted with the intimate nature of sight, than with that of all the other senses, and that we shall never be able to learn why these are the conditions of the ideas it procures us.

Rays which proceed from any point, necessarily

farily diverge as they advance, and therefore cannot re-unite in another point unless they are refracted by some transparent body through which they pass. This takes place in the eye, in the same manner as in the optical instrument called a *camera obscura*. The eye is perforated by a hole named *pupil*, behind which there is a transparent body of a lenticular form called *crystalline*, more dense than the medium in which the animal exists, and than the other fluids contained in the eye. The cone of rays which proceeds from any luminous point to the pupil, forms, after passing through the crystalline, another cone, the apex of which falls upon the retina. These two cones have their axes almost in a straight line. That which is perpendicular to the middle of the crystalline proceeds directly to the bottom of the eye; that which comes from above, falls inferiorly; that of the left proceeds to the right, and so on with respect to the others. Thus an inverted image of the object is formed on the retina; but as we judge of the situation of each luminous point by the rays it transmits, it follows that we must see bodies, as we really do see them, in their proper position.

If the rays were parallel, they would unite in the point which is called, in Dioptrics, the *focus of parallel rays*; but as those which come from a point, the distance of which is finite, diverge, they unite in a point a little more removed from

the crystalline than this focus ; and as those which proceed from a very near point, diverge still farther, they also unite still more remotely.

A particular eye therefore sees distinctly only objects placed at a certain distance. If its crystalline has much refractile power, that is to say, if it is very dense and very convex ; or, if its retina is removed from the crystalline, it can only distinguish near objects : if its crystalline is flat and less dense, or its retina too close to the crystalline, it will only distinguish distant objects.

This produces different extents of sight in one man compared with another, and still greater differences in the various kinds of animals.

The same man may, with some attention, distinguish the same object at different distances, the limits of which may be assigned with respect to each individual.—Certain animals can discern objects, the distances of which are extremely variable. Birds, for example, perceive their prey from immense heights in the air, and still retain it in view until they seize it : it must follow therefore, that the eye is capable of changing the position of its parts, by approximating and removing the retina with respect to the crystalline ; or that it is capable of augmenting its refractile power by increasing the convexity of some of its transparent parts ; or finally, that, in viewing very near objects, it only admits the rays which are nearest to the axis, and which
are

are consequently the least diverging. We shall point out hereafter the means by which each of these changes is supposed to take place. None of these means however completely resolve the problem. Perhaps the limits of distinct vision are much more confined than we imagine them to be ; and it is probable that, in many cases, it only appears distinct, because it is assisted by the recollection we have of the object.

Before the crystalline there is usually an humour, called *aqueous*, equal in density to pure water ; and behind it there is always another, which is much more abundant, and a little more dense, named the *vitreous*. The *aqueous* is only wanting in some animals which live always in water. It is supposed that the union of these three bodies, of different densities, must produce the same effect as the three objective glasses in achromatic telescopes, that is to say, they correct the difference of refrangibility in the rays. These rays are indeed usually compound. The white consist of seven simple rays ; and as they are not all refracted at the same angle, the images formed on the retina would, as in those produced by common telescopes, be bordered by an iris, if this disposition of the three humours did not exist.

The eye, however, sometimes sees what are called *accidental colours*. When the retina is too much fatigued by certain colours, it becomes less sensible of them. If we then behold a colour

lour which admits in its composition that which had fatigued the eye, the latter will cease to be visible.

Thus when we fix the eye on a white spot, and afterwards turn it towards white bodies, we observe on them a dark spot of the same shape as that to which the eye was first directed. If the spot on which the eye was fixed was black, the eye, wherever it turns, will perceive one of a lighter colour. If it was red, we observe a greenish spot on white bodies; if yellow, a bluish; if green, a reddish, &c. &c.

It must not be forgotten, that the aqueous humour has also, by its convexity, a great influence on the refraction of rays, particularly in animals which live in air. That convexity, joined to what is possessed by the vitreous, probably supplies the effect of the crystalline in eyes which have undergone the operation of the cataract, that is to say, when the crystalline has been removed on account of its opacity.

A number of animals can only see the same object with one eye at a time. Man also employs only one when he wishes to see very distinctly. In ordinary vision, when the images fall on the corresponding points of both retinae, and when both eyes are nearly equal, we do not distinguish these separate images, and we see objects simple: but if one eye be turned in a different direction from the other, or if they be very unequal, we see double.

ARTICLE II.

Of the Number, Mobility, relative Magnitude, Position and Direction of the Eyes in different Animals.

ALL red-blooded animals, without exception, have two moveable eyes placed in the cavities of the cranium, called orbits, and composed of the same essential parts as those of man. None have either more or less. There are merely some apparent exceptions, when the eyes are concealed by the skin, as in the *zemni* (*mus typhlus*), or when the same eye, having two pupils, appears double, as in the fish called *cobitis anablebs*.

The same observation applies to the *mollusca cephalopoda*, or *cuttle fish*.

The greater part of the *gasteropoda* have also two eyes, but very small, and placed either on a level with the head, or on some of the fleshy and moveable tentacula. In some they are situated at the base of these tentacula; in others, at the middle or the point, as may be learned from the writings of naturalists. In all this order, only the genera *clio*, *scyllea*, and *lernea*, want the eyes.

In the mollusca of the order *acephala*, no eyes are found.

The eyes of insects appear to be of a different
nature

nature from those of the animals we have hitherto mentioned. They are divided into the *compound* or *flagrined*, the surface of which, when viewed by the microscope, presents a multitude of tubercles; and the *simple*, which presents only one tubercle.

All the *coleoptera* and the *butterflies* have only two compound, without any simple eyes. These eyes are sometimes divided by a bar, and then appear double. This takes place in the *water fleas*; it is said that simple eyes have been observed in some *moths*.

The *orthoptera*, the *hemiptera*, the *hymenoptera*, the *neuroptera*, and the *diptera*, have, with some exceptions, two compound eyes, and three simple, placed between the former. Among the exceptions are the *ephemeræ* and the *phryganeæ*, which have two simple eyes exceedingly large in some species of the first genus; and the *hemerobii* and *lion-ants*, which have only two simple eyes.

All winged insects have compound eyes.

Among those that want wings some have them compound, as the *onisci*; others have them simple, viz. the *phalangii*, four; the *spiders* and *scorpions*, six or eight; the *julus* and *scolopendra*, a considerable number; lastly, others, as the *lepisma* and the *limulus*, have them of both kinds.

Gray-fish have almost all their eyes compound, and placed on moveable peduncles.

The larvæ of insects, which undergo a semi-
meta-

metamorphosis, have their eyes similar to those of the perfect insects, but the larvæ of insects that are completely metamorphosed, always have simple eyes, which vary greatly as to number in the different species. The *caterpillars*, for example, have six on each side. The *false caterpillars*, or larvæ of the *saw flies*, have only two: those of the *bees*, *stratyomes*, &c. have the same number. Several of the larvæ which undergo a complete metamorphosis, have no eyes at all.

An infinite number of other observations might be made, respecting the form, position, and direction of the eyes of insects, and of their larvæ, and on the effects thereby produced on their vision; but as these circumstances are external appearances, we shall leave the description of them to naturalists.—See Article XIII.

Among the articulated worms, there are sometimes found small tubercles, which have been regarded as simple eyes, in consequence of their resemblance to those of insects. Some *leeches* have two, four, six, or eight. In some of the *neréides* we find two or four. In some *naïdes* only two, &c.

No parts that can be compared to eyes, have hitherto been observed in any zoophyte.

The eyes are always situated in the head, except in some insects that have no wings, in which the head is confounded with the corselet, that is to say, in the *spider*, *phalangium*, *scorpion*, &c.
The

The relative magnitude of the eye varies, without any relation to the classes, or even to the natural genera. Large animals, however, have, in general, the eye proportionally small: this is observable in the Cetacea, and in the *elephant*, *rhinoceros*, and *hippopotamus*.

It is also very small in the animals that live constantly under ground, as the *moles*, *shrews*, *mole-rats*, and some *field-mice*.

The frugivorous mammalia, that climb trees, have in general the eye large, as the *makis*, *squirrels*, *dormice*, &c.

A very large eye most commonly indicates that the animal can see in the dark. *Bats* form no exception to this rule, because it appears that they are not directed by their sight in flying, as we shall shew when we treat of the sense of feeling.

Almost all fishes have large eyes; doubtless because they live in a medium which is more obscure than the atmosphere.

The cephalopodous mollusca have them very large, particularly the *calmar*: on the contrary, in such of the Gasteropoda as possess eyes, they are scarcely visible.

If we examine all the *chagrined* and *smooth* eyes of insects, we will find that they present larger ocular surfaces to the light, than any animal of the other classes, though each particular eye is very small.

The eyes of man and monkeys are directed forward.

forward. The *tarsier* (*Lemur tarsius* Pall. *Delphis macrotarsus* Gmel.) is of all the Mammalia that in which the eyes are situated nearest each other.

In the other quadrupeds the eyes are always more separate, and situated towards the sides. They are directed a little downward in the Cetacea. In birds their position is lateral, except in the *owls*, in which they look forwards as in man.

In all reptiles they are on the sides of the head.

Fishes vary greatly with respect to the position of the eyes. Some have them turned straight upward, as in the *star-gazer*; in others they are directed obliquely, as in the *callyonymus* and the *ray*. Some have them both situated on the same side of the body, as the *pleuronectes*. In the greater number of fishes, however, the eyes are placed laterally.

All animals, in which the situation of their organs is perfectly lateral, can contemplate objects only with one eye at a time.

ARTICLE III.

*Of the entire Figure of the Globe of the Eye;
of the Form and Proportion of its Chambers;
and of the Density of its transparent Parts.*

BEFORE we proceed to consider the eye as a dioptric instrument, it is of importance to acquire a knowledge of the circumstances which may determine the general effect that organ produces. These consist in the forms, proportions, and density of the crystalline lens, and of the two humours which accompany it.

A. *Form.*

The general form of the eye depends on the nature of the medium, in which the animal it belongs to exists. It is almost spherical in man, and in the quadrupeds that live on the surface of the earth; that is to say, in the lowest and most dense part of the atmosphere. The cornea forms a slight projection at its anterior part, because its convexity is the portion of a sphere, which is smaller than that of the rest of the eye; this difference, however, is not apparent in the *porcupine, opossum, &c.* The globe is in general

neral a little more convex anteriorly, than posteriorly *.

In Fishes, and the Cetacea, which inhabit the water, the flatness of the anterior part of the eye is much more considerable. Indeed, in a great number of fishes, the eye represents a semi-sphere, the plane part of which is forward, and the convex backward. In the ray, the superior part is also flattened, so that the eye ap-

* To ascertain with still more precision how far the globe of the eye approaches to, or departs from a true sphere, we may form a table of the proportion of its axis to the transverse diameter, in the following manner :

	Axis.	Transverse diameter.
Man.....	1 :	1
or.....	137 :	136
Monkey.....	The same.	
Dog.....	24 :	25
Ox.....	20 :	21
Horse.....	24 :	25
Whale (measured internally).....	6 :	11
Porpoise (measured externally).....	2 :	3
Owl.....	13 :	12
Vulture.....	13 :	16
Ostrich.....	4 :	5

As some eyes depart from the circular form, in their section from right to left, we might also form a table of the proportion of their vertical diameter, or height, to their transverse diameter, or breadth. The following are two examples :

The height is to the breadth—

In the ox, as.....	37 :	38
In the ray, as.....	1 :	2

appears like a quarter of a sphere, divided by two great circles, perpendicular to each other. Some fishes, particularly the *gadus lota* Lin. form exceptions to this rule, and have also the cornea very convex.

In birds, which are always more or less elevated in the atmosphere, the eye departs from the spherical form, in a direction contrary to that of fishes. On its anterior part, which is sometimes flat, sometimes in the form of a truncated cone, a short cylinder is engrafted: this cylinder is terminated by a cornea, which is very convex, and sometimes completely hemispherical, but which always belongs to a much smaller sphere than the posterior convexity.

In *owls*, in particular, the conical part is most considerable; its axis is double that of the posterior part; but in the other birds, the cone is commonly very flat. In the *vulture*, its axis is one half of that of the posterior part, or the segment of the sphere.

This difference in the eyes of the three classes depends on the proportional density of the media the animals inhabit, compared to that of the aqueous humour of the eye. As this humour is equal in density to water, it cannot refract rays in that medium, and would therefore be of no use to fishes. Thus we find, either that it does not exist at all in these animals, or that they possess it in a very small quantity.

In

In air which is very much rarefied, as that in which birds fly, the refrangibility of the aqueous humour is considerable. It is therefore abundant in them, and presents a very convex surface. Quadrupeds occupy a middle place between these two classes, both with respect to the structure of their eye, and the medium they inhabit. The aqueous humour is entirely wanting in the *cuttle-fishes*.

The convexity of the crystalline lens is in an inverse proportion to that of the cornea; and consequently its thickness bears an inverse ratio to that of the aqueous humour.

The crystalline of fishes is almost spherical, and sometimes even perfectly so; it projects through the pupil, and leaves scarce any space for the aqueous humour. We also find the convexity of the crystalline very great in the Cetacea, and in some quadrupeds, and birds that dive frequently, as *seals*, *cormorants*, &c. It is likewise very convex in reptiles.

The form of the crystalline in birds, is that of a flat lens. In the Mammalia it is more convex. Of all mammiferous animals, man has it most flat. In all these animals it is composed of two segments of a sphere, the posterior of which generally belongs to a smaller sphere* :

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its

* The following table of the proportion of the axis to the diameter, affords an opportunity of comparing the convexities of different crystallines. It is founded partly on the observations

its dimensions and proportions are not entirely constant in each species; it is generally more convex in young subjects than in old.

It is obvious that this convexity of the crys-

tians of Petit, (*Memoires de l'Academie des Sciences*, 1727,) and partly on our own.

The axis is to the diameter—

In Man, as	1 : 2 generally
the Monkey	The same
Ox	5 : 8
Horse	2 : 3
Dog	7 : 9
Hare	4 : 5
Otter	4 : 5
Porpoise	9 : 10
Whale	13 : 15
Owl	3 : 4
Parrot	7 : 10
Vulture	8 : 11
Tortoise	7 : 9
Frog	7 : 8
Salmon	9 : 10
Sword-fish	25 : 26
Shad	10 : 11
Pike	14 : 15
Barbel	11 : 12
Carp	14 : 15
Mackrel	12 : 13
Whiting	14 : 15
Shark	21 : 22
Ray	The same
Herring	10 : 11
Tench	7 : 8
Eel	11 : 12
Congre	9 : 10

talline

talline is capable of supplying the deficiency of that of the cornea. In animals which have the cornea convex, when the already converging rays arrive at the crystalline, it is not necessary that they should be greatly approximated by that lens: the contrary is the case in those which have the cornea flat.

B. *Proportions.*

To ascertain the space occupied by the crystalline, and the two humours, the eyes must be congealed, and divided in that state by a plane passing through their axis. This experiment is, however, attended by the inconvenience of producing an unequal dilatation in the different parts of the eye; but it enables us to discover that the crystalline occupies least space in the human eye, and most in that of fishes.

The portion of the axis occupied by each of the three parts of the eye, may be represented by the following fractions; the length of the axis being considered the unit:

	Aqueous humour.	Crystalline lens.	Vitreous humour.
Man.....	$\frac{3}{12}$	$\frac{4}{12}$	$\frac{15}{12}$
Dog.....	$\frac{5}{11}$	$\frac{8}{11}$	$\frac{8}{11}$
Ox.....	$\frac{5}{17}$	$\frac{14}{17}$	$\frac{8}{17}$
Sheep.....	$\frac{4}{17}$	$\frac{11}{17}$	$\frac{12}{17}$
Horse.....	$\frac{9}{13}$	$\frac{6}{13}$	$\frac{8}{13}$
Owl.....	$\frac{8}{17}$	$\frac{11}{17}$	$\frac{8}{17}$
Herring.....	$\frac{1}{7}$	$\frac{5}{7}$	$\frac{1}{7}$

It would be also interesting to learn the proportion of the total space occupied by each of these transparent parts. Among the mammiferous animals, the eye of man has the vitreous humour most abundant; it is twenty times greater than the aqueous: in the ox, it is ten times; and in the sheep, nine times greater.

C. *Density.*

If the following table, given by Monro, of the specific gravity of the different transparent parts of the eye in the *ox* and the *cod* be correct, we may conclude that the differences with respect to density between the mammalia and fishes are not considerable. Distilled water is here supposed a thousand.

SPECIFIC GRAVITY.

	In the Ox.	In the Cod.
Of the aqueous humour	1000.....	1000
Of the vitreous humour.....	1016.....	1013
Of the whole crystalline	1114.....	1165
Of its external part	1070.....	1140
Of its nucleus.....	1160.....	1200

It should be remarked, however, that the power of refraction is greater than the density indicates, in consequence of the partly inflammable nature of the humours of the eye. It is also possible that these humours contain more inflammable parts in some species than in others, and that their refrangibility cannot, therefore, be precisely in the ratio of their density.

D. *Con-*

D. *Consistence.*

The crystalline is hardest in those animals in which it is most convex. The human crystalline is one of the softest: that of the other mammiferous animals and birds may be easily bruised; its middle part is, however, hard. In fishes, that part forms a nucleus, which cannot be divided without some difficulty. The crystalline is also very hard in the *cuttle-fish*: its induration increases with age in all animals.

The external and softest parts of the crystalline are also the least dense; it is probable that this disposition prevents that reflection of the rays which would in a certain degree take place, were they suddenly transmitted through three different media; this happens in the passage of the rays, through the objective glasses of the achromatic telescope; and the milky cloud which results from these repeated reflections, is one of the principal defects of this instrument.

The aqueous humour, which is very fluid in warm-blooded animals, is viscous and filamentous in fishes.

The consistence of the vitreous humour is in general similar to that of the white of an egg: as it is contained in cells, it has the appearance of a body which is circumscribed, and not fluid. This has induced a great number of anatomists to name it the *vitreous body*.

The preceding data are not sufficient to enable us to calculate the effect of the eye accurately. It is also necessary that we should know the exact length of the radii of the spheres, to which the anterior and posterior curvatures of the cornea and crystalline belong in each animal; and likewise the length of the axis of the aqueous, crystalline, and vitreous humours. Lastly, the refractile power of these three transparent bodies compared with that of distilled water.

We might then determine the focus of parallel rays, and the distance at which the animal can easily distinguish objects. By adding to these principal points the observations we shall presently make respecting the means possessed by the different classes of animals, for changing the figure of their eye, we would ascertain the limits of their visual faculty.

But the dimensions I require are very imperfectly known to us: the following is, however, a table of them, drawn up from the writings of Petit, Monro, and my own observations:—

	RADIUS of the curvature of the cornea.	RADIUS of the anterior curvature of the crystalline.	RADIUS of the posterior curvature of the crystalline.	AXIS of the aqueous humour.	AXIS of the crystalline lens.	AXIS of the vitreous body.
Man	0,017	0,016	0,012	0,003	00,045	0,014
Dog	0,014	0,012	0,005	0,008	0,008
Ox	0,025	0,021	0,006	0,014	0,017
Sheep.....	0,004	0,010	0,012
Horse.....	0,009	0,116	0,019
Rabbit	0,014	0,014	.....	0,011	.....
Porpoise, 1,5.....	0,016	0,014	.....	0,012	.....
Turkey.....	0,012	0,009	.....	0,005	.....
Horn Owl	0,014	0,016	.....	0,012	.....
Salmon, 0,5.....	0,008	0,004	.....	00,045	.....
Pike, 0,65	0,010	0,009	.....	0,008	.....

We are almost entirely ignorant of the refractive power of the three humours. To calculate that of the crystalline, the curvatures of which are well known, it is necessary to measure at what distance it collects the parallel rays. According to *Monro*, in the crystalline of an *ox*, the radius of the anterior curvature of which was $\frac{2\frac{1}{8}}{40}$ of an inch, and that of the posterior $\frac{1\frac{5}{8}}{40}$, the focus was $\frac{1\frac{3}{4}}{40}$ behind the posterior surface; and in the crystalline of a *cod-fish*, where the radii of the curvatures were $\frac{1\frac{4}{8}}{40}$, and $\frac{1\frac{3}{4}}{40}$ and a half, the focus was only $\frac{3}{40}$ when in the air, and $\frac{1\frac{6}{8}}{40}$ in water: but he does not state the thickness of the crystallines, nor explain what measure he used.

ARTICLE IV.

Of the First Coat of the Eye, or the Sclerotica.

THE Sclerotic covers the whole globe of the eye, the anterior part excepted, where it leaves a large vacancy, which is filled up by the cornea.

The sclerotic determines the shape of the eye; it therefore can be really soft and flexible only in animals that have the eye nearly globular, that is to say, in men and quadrupeds, because their sclerotica assumes of itself that shape, in consequence of the nearly uniform resistance made by the fluids contained in the eye to the pressure of its coats: but in all animals that have the eye more removed from a spherical form, as the Cetacea, fishes, and birds, that membrane is supported by hard accessory parts, or by a greater solidity of texture, and a more considerable thickness.

In man, and in most mammalia, the sclerotica is a whitish opaque membrane, somewhat soft, moderately thick, and presenting, at first sight, no apparent organization. It is resolved, however, by maceration, into a cellular texture, composed of filaments interwoven in every direction. This structure may be discovered without preparation in the eye of Cetacea, and particularly in that of the *whale*; in this animal

mal the lateral parts of the sclerotica are nearly an inch thick, and its bottom nearly an inch and a half; the lateral parts are very hard. On cutting into them, we observe that their substance consists of fibres which have a tendinous appearance, and which form a kind of net-work, the meshes of which contain another substance of a fungous nature, browner and more flexible than these fibres: the posterior part is much softer, because the meshes are there larger, and partly filled by an oily substance; these two substances, the soft and the hard, are separated in a very abrupt manner, and do not run gradually into each other.

The optic nerve passes through the posterior portion of the sclerotic, by a canal an inch and a half long, the parietes of which are formed by the dura-mater; and it is very visible that the white fibres which form the base of the sclerotic, are successively detached from the external surface of the dura-mater, of which they appear to be an expansion. This seems to decide the question, whether the sclerotica be a continuation of the dura-mater, in favour of the ancients. The question is, however, very difficult of solution in other animals, in which these two membranes touch only by a very thin portion. The sclerotic of the *porpoise* is only two or three lines thick, but it presents the same structure as that of the *whale*. In the true quadrupeds, this membrane differs in nothing essential

essential from that of man ; in both it is generally thickest at the anterior part, which is occasioned by the tendons of the muscles of the eye being inserted there.

In the *seal* the sclerotic is thick anteriorly, and still more posteriorly, but the middle zone is thin and flexible.

The sclerotic of birds is thin, flexible, and rather elastic posteriorly ; it has a bluish and brilliant appearance, but we perceive in it no distinct fibres ; it does not receive the optic nerve by a simple hole, but by a canal, which passes obliquely through its substance ; its anterior part is divided into two laminæ, the interval of which receives a circle of small thin hard oblong bones, which lie over each other like tiles, and which give to the anterior part of the edge a great degree of firmness, and a fixed form. These ossicula are almost flat in the greater number of birds, in which they form only an annular disk of little convexity ; they are slightly arched and concave externally in the *horned owl*, in which they form a short tube, in the shape of a truncated cone. They are usually twenty in number.

The *tortoise* has, at the anterior part of the sclerotic, the same osseous laminæ as birds ; these laminæ are enclosed in that membrane, without being continued into its substance, and may be easily separated from it.

There are similar laminæ in the sclerotic of
the

the *camelion*, and in that of several other *lizards*; but they do not form the anterior disk; they merely surround the lateral part.

In fishes the sclerotic is cartilaginous, homogeneous, semi-transparent, elastic, and sufficiently solid to preserve its form of itself, though very thin in some species. In the *ray* it swells posteriorly into a tubercle, by which the eye is joined to a particular stalk, of which we shall speak hereafter. The sclerotic of the *sturgeon* is thicker than the cavity of the eye; it represents a kind of cartilaginous sphere, a part of which contains a small cavity, covered by the other membranes.

The *salmon* has the sclerotica, of the thickness of a line posteriorly, and of an almost bony hardness before. This induration of the anterior portion is observed in a number of other species.

The sclerotic of the *sepia* is singular. Posteriorly it is much removed from the globe of the eye. The large ganglion of the optic nerve and several other glandular parts are situated between them. The sclerotica, therefore, forms posteriorly a truncated cone, the pointed part of which is directed to the bottom of the orbit; to this portion the muscles are attached: the anterior part nearly shuts the globe of the eye; it is very soft and viscous; it is easily separated, and presents a coarse felt-like texture, which becomes firmer in spirits of wine. In

some species it has a metallic brilliancy. As there is no cornea, the sclerotic is wanting opposite to the crystalline; but the hole is not sufficiently large to admit a view of the iris, without dissection.

In all animals, the sclerotic is double: a very thin, and usually blackish membrane, closely adheres to its internal surface, and is believed to be a prolongation of the pia-mater. In the *lion* we have been able to follow it with ease under the cornea, where it becomes firm and transparent, and from which it may be detached with facility.

The sclerotica not only affords insertions for the straight and oblique muscles of the eye, but also for those of the third eye-lid in birds, and and in a number of reptiles. In all the classes it transmits, through holes which perforate it, the optic nerve, the ciliary nerves, and the internal vessels of the eye.

From its flexibility in man and quadrupeds, it is believed that the muscles compress it, and that the humours being thus pushed forward, swell the cornea, and render the eye capable of distinguishing very near objects. It cannot, however, have this use in animals, in which it is wholly or partly inflexible, as in the Cetacea, birds and fishes: yet their powers of distinct vision are, in a number of species, at least greater than those of man.

ARTICLE V.

*Of the transparent Cornea, and of the Con-
junctiva.*

THE *cornea* is that transparent part which seems encased in the vacancy left by the sclerotic at the fore-part of the eye. We have stated, in Article III. its varieties with respect to convexity: it also presents some differences in its shape.

It is not always completely circular: in man, and other mammalia, it is more broad than long, and contracted a little towards the side of the nose.

Its transverse diameter or breadth is, to its height,

In the ox, as $27 : 23$.

In all animals the cornea is composed of thin transparent laminæ, glewed together by compact cellular matter, and forming, by their union, a plate which is thicker in the middle than towards the edges. This part is, therefore, of itself calculated to produce a convergency of the luminous rays; its laminæ are easily separated by the scalpel, especially after a little maceration.

According to the experiments of Home, the cornea becomes more convex when we examine

near objects, and more plain when we look at those that are distant: in the first case it approximates more powerfully the most diverging rays.

Some have attributed this effect to the contraction of the ciliary processes, others to that of the iris. It is more probable that it is produced by the straight muscles of the eye; but it is not sufficient to explain distinctness of vision at very different distances.

The cornea is the only part to which we find an analogy in the eyes of insects; it even appears in them to supply the place of the crystalline. It is entirely hard and scaly.

The cornea was long supposed to be a continuation of the sclerotic, but is now acknowledged to be a particular membrane. It is not, however, always attached to the sclerotic, simply by cellular substance: the edges of the two membranes sometimes penetrate reciprocally into each other. This is particularly observable in the *whale*. The fibres of the sclerotic in that animal, pass into the substance of the cornea in the form of very delicate white lines, but pretty long and conspicuous. These lines are also easily distinguished in the *rhinoceros*.

The line of separation of these two membranes is sometimes straight, as in the *whale*, *rhinoceros*, &c.; at other times it forms a kind of bevel or slope, and the cornea slides under the edge of the sclerotic. This is the case in *man*,
the

the *ox*, &c. in some other animals the edge of the sclerotic is double, and embraces that of the cornea in the manner of a forceps. The *hare* affords an instance of this kind of connection.

The separation of the cornea from the sclerotic, may in particular be distinctly observed in the *tope* (*squalus galeus*.) These membranes form a slope or bevel, but in such a manner that it is the sclerotic which becomes thin behind the cornea, and not the latter as is commonly the case. The sclerotica is white, the cornea yellowish, and there is besides, between the two, a compact but very conspicuous cellular texture. This substance appears to be a production of the conjunctiva, which penetrates the eye, to unite with the ciliary ligament and the iris.

The *sepia* have no cornea, and the anterior aperture of the sclerotic is not filled up. The crystalline projects across it, and there is no aqueous humour. We find, however, under their conjunctiva, a particular membrane which is dry, fine, and transparent: it envelopes the sclerotica itself, and the anterior part supplies the place of the cornea.

The *conjunctiva* is that part of the skin which, after being reflected, to line the internal surface of the eye-lid, where it assumes a finer texture, and receives more numerous vessels, folds back again in the contrary direction, and, becoming still finer, covers the anterior part of the eye.

It adheres very closely to the cornea, from which it cannot be separated, except by maceration. The part of the conjunctiva which covers the cornea, is transparent; that which spreads over the sclerotic, is what we call the white of the eye, and is, in fact, of that colour when its blood-vessels are not distended, or rendered too visible by inflammation.

This description, taken from man, applies to all animals which have eye-lids, with the exception of the colour of the part analogous to the white of the eye, which sometimes varies; but in the species which have no eye-lids, as in the greater number of fishes, the skin passes directly before the eye without forming any fold: sometimes it even does not adhere very closely to the eye. This is particularly observable in the *eel*, which may be skinned without producing any hole in the situation of the eye, the skin only exhibits at that place a round transparent spot. It is the same case in the *serpents* and *cuttle-fish*.

In the *trunk-fish* (*ostracion*) the conjunctiva is so similar to the rest of the skin, that we observe lines upon it which form the same compartments as on the body of the fish.

Among the mammalia we find a kind of *rat* in which the skin is not even transparent over the eye, but is there covered with hairs, as on the rest of the body. The eye, which is scarcely the size of a poppy-seed, is perfectly useless.

This rat is the *zemni* (*mus Typblus*.) An eel (*murena cæcilia*,) and the *myxine* (*gastrobranchus cæcus*.) are blind in the same manner, in consequence of the opacity of the conjunctiva.

ARTICLE VI.

Of the Second Coat of the Eye, or the Choroides and its Appendages.

A. In Man.

THE choroides lines all the sclerotica interiorly, in the concavity of which it is formed. In the greater part of their extent, these two membranes are only attached by a very loose cellular substance, but they are connected by nerves and vessels which perforate the sclerotic to proceed to the choroides, or to pass through it. Their anterior part, that which is next the cornea, is more intimately united by a circle of a cotton-like cellular substance moistened by a whitish mucus. This is called the ciliary ligament. It is thicker and more compact anteriorly: it becomes thinner and disappears posteriorly. At the surface opposite to this ligament, that is to say, on the concave surface and around the anterior edge of the choroides, we observe its internal lamina forming very fine folds, disposed

in radii; they have some resemblance to the disk of a radiated flower, and are named altogether *corpus ciliare*. The projecting laminæ which result from these folds, have their anterior extremity a little turned towards the axis of the eye as they retreat from the cornea. Thus all the extremities of these laminæ intercept a circular space, which is precisely the position of the crystalline. It even appears that these extremities, which are called *ciliary processes*, are attached to the front of all the more acute border of the capsule of the crystalline, and contribute to render it fixed. The laminæ which compose the corpus ciliare, make hollow impressions on the anterior surface of the vitreous humour which occupies all that part of the eye situated behind them.

After having produced, by these internal projecting folds or laminæ, the beautiful wreath which we have just described, the choroides proceeds to form an annular veil, placed between the cornea and the crystalline, which is called the *uvæa*: it is perforated in its middle by a hole named the *pupil*, and its anterior surface covers another membrane, which is also annular, and which is visible through the cornea. This membrane is the *iris*, which we shall describe in the next article.

That part of the second tunic which is situated before the crystalline, is almost plain in man. It sometimes has a degree of convexity in
other

other animals, but always less than the rest of the coat, which has precisely the same curvature as the sclerotica.

The first chamber of the eye is situated between this flat part of the second tunic, and the greatest convexity of the cornea. The aqueous humour fills this chamber.

The substance of the choroides is very thin and delicate; good injections shew that it is almost entirely composed of a triple vascular texture. Its arteries form, in the first place, the external part: the greater number pass through the sclerotic, very near the optic nerve, and are distributed over the whole choroides, where they divide at very acute angles: they are named the *short ciliary arteries*, to distinguish them from two trunks which almost reach the iris without dividing, and which are named the *long ciliary arteries*. The internal texture is formed by the extremities of the same arteries, which having pierced the choroides, form on its internal surface a net-work so uniform and so fine, that the reticular interstices cannot be distinguished except by a very strong magnifying glass. The third texture is intermediate; it is formed by the veins, the course of which is very singular. They represent irregular arches, which meet at certain points, and form a kind of circle. These are the vessels which we see most distinctly without injection.

The internal surface of the choroides is lined,

in man, by a dark-coloured, or even perfectly black mucus, which may be removed or washed off with the finger or a pencil. It serves to prevent the rays, reflected by the internal parietes of the eye, from disturbing vision, which is effected by direct rays. For the same reason all dioptric instruments are blackened internally. When this pigment is removed, we can see by a magnifying glass a slight villosity. The internal lamina of the choroides seems of a more solid texture than the rest of its body, and is particularly named *membrana Ruyschiana*.

The ciliary processes and the uvea have the same vessels, the same villous surface, and the same black varnish as the rest of the choroides. The ciliary processes even leave a remarkable impression of this varnish on the anterior part of the vitreous body, when they are separated from it. This cannot be done by the rest of the membrane, on account of the position of the retina.

B. *In other Animals.*

The choroides exists in the eyes of all animals which are known to us. It is always vascular, and at least partly covered on its concave surface by a particular mucous substance; it varies with respect to the ciliary processes, the colour and texture of its posterior part, the separation more or less easy of the *membrana Ruyschiana*, and the disposition of its blood-vessels.

I. *Of*

1. *Of the Ciliary Processes.*

The mammalia and birds have all the ciliary processes: we find them also in some reptiles, and even in the *cuttle-fish*, but they are wanting in almost all fishes.

In man, each of the laminæ of the ciliary processes represents a long irregular triangle; the side by which the lamina joins the rest of the choroides, is convex; another, which touches the vitreous body, is concave; and the third, which is next the iris, is much shorter than the other two. The angle which touches the capsule is rounded, all the three edges are slightly denticulated. This denticulation is much more apparent, and even changes into a real fringe in the large animals, as the *ox*, the *horse*, and the *rhinoceros*. It is also similar in the *whale*, in which the angle that retains the capsule, is prolonged more into a point than in the preceding species. In the *Sarcophaga*, particularly in the *lion*, the side which forms the base of the laminæ, is shorter in proportion to the other sides than in the preceding animals, so that the opposite angle projects most: we perceive no denticulation on its edges. In all these species, one lamina out of two or three, is shorter than the others; but in this respect a regular order is not observed.

In birds the ciliary processes project little; they are almost merely ferrated striæ, a little

undulating. There are, however, differences in the species.

In the *horn-owl* they are fine, compact and numerous. In the *ostrich* they are larger and more loose, but in all birds their extremity adheres very firmly to the capsule of the crystalline.

In the *tortoise* the ciliary processes project so very little, that we could scarcely recognize them, were it not for the elegant impression they leave on the vitreous body; but in the *crocodile* these processes are very beautiful, and very conspicuous; they are each terminated by a nearly right angle. I have observed these processes in the form of elongated threads, but few in number, in a large foreign *tree-frog*; they are also such, though not distinct, in the *toad*. I have not observed them in the common *lizards*, nor in the *serpents*.

There is a very conspicuous body and ciliary processes in the *squalus, galeus*: the laminæ project almost as much as in birds, and, after forming a short point, which joins the capsule of the crystalline, they are continued with the striæ of the uvea. I have not been able to perceive the same structure in the *ray*, but it is certain that there is nothing similar in the osseous fishes; their uvea passes on, without interruption, with the membrana Ruyfchiana, and forms with it an uniform tunic, no part of which projects inwardly.

The use of the ciliary processes, in retaining the

the crystalline, is no where so distinctly seen as in the eye of *cuttle-fishes* and *pulps*: their ciliary processes form a large zone or diaphragm, in the aperture of which the crystalline is truly encased. A deep circular furrow passes completely around the crystalline, and divides it into two unequal hemispheres. The ciliary processes penetrate into this furrow, where they are so firmly fixed, that they cannot be removed without being torn. The process is not formed of projecting laminæ, but of a continued membrane, the two surfaces of which are marked by a circle, consisting of a vast number of very fine radiated striæ, which present a very agreeable spectacle to the eye.

2. Of the *Membrana Ruyschiana*.

This membrane can scarcely be distinguished from the choroides in *man*, *monkies*, *small quadrupeds*, and *birds*; but in the *large quadrupeds*, although we cannot separate it without injuring both membranes, it is distinguished by its finer, more compact, and seemingly homogeneous texture. The section of the choroides presents to the microscope only the open mouths of the small vessels which compose it. That of the *Ruyschiana* is solid, and resembles the section of a simple membrane; for example, of the epidermis. This is particularly observable in the eye of the *whale*, where the apertures of the vessels

sels are visible to the naked eye, and where the three layers are easily discovered.

The lateral and anterior parts of the Ruyfchiana are, as we have observed, covered with a mucous pigment, more or less dark; it is of a purple red colour in the *calmar*, which, with the other *sepia*, form probably the only exception to this rule. Some birds have it of a deep-brown red. This varnish is sometimes wanting in certain species, in consequence of a disease which also whitens their hair: the *white rabbits*, *white negroes*, and *white mice*, form examples of this variety: their Ruyfchiana is then transparent, and all the parts of the choroides would be of a white colour, if it were not for the numerous vessels distributed in that membrane, which give it a lively red appearance.

3. *Of the Tapetum.*

The bottom of the Ruyfchiana is frequently covered with a very slight coat of this pigment, through which we can perceive its colour, which varies remarkably in different species. *Man* and *monkeys* have it brown or blackish. *Hares*, *rabbits*, and *hogs*, of a chocolate brown colour; but the *Sarcophaga*, the *Ruminantia*, the *Pachydermata*, the *Solipeda*, and the *Cetacea* have lively and brilliant colours in this part. The *ox* has it of a beautiful green, changing into azure blue. The *horse*, the *goat*, the *buffalo*, the *stag*,

Ag, of a silver blue, changing to violet. The *sheep*, of a pale yellow green, sometimes blueish. The *lion*, the *cat*, the *bear*, and the *dolphin*, have it of a pale golden yellow. The *dog*, the *wolf*, and the *badger*, of a pure white, bordered with blue. This coloured part of the Ruyfchiana is named the *tapetum* : it does not occupy all the bottom of the eye, but merely one side, that which the optic nerve does not perforate.

It is difficult to account for the use of this brilliant spot in a place so little visible. Monro, and others before him, have supposed that the tapetum of the ox is green, in order to represent to him, more strongly, the colour of his natural food ; but this explanation does not apply to the other species.

Birds and fishes have no tapetum ; their Ruyfchiana is uniformly blackish, and covered every where by mucous substance ; there is even much more on its bottom than any where else in fishes. The *ray* forms an apparent exception to this rule ; there is at the bottom of its eye a beautiful silver colour, produced by the transparency of the Ruyfchiana, which allows the colour of the choroides to be seen through it.

4. *Of the Choroid Gland of Fishes.*

The Ruyfchiana and choroides of fishes form two membranes, which are very distinct, and easily separated. The Ruyfchiana is black, and composed of an interlacement of innumerable vessels.

vessels. The choroides is either white, silvery, or gold coloured; it is very thin, and little vascular.

Between these two membranes there is a body which some have named a gland, others a muscle, and which deserves to be described: it is usually of a lively red colour; its substance is soft, and rather glandular than muscular; at least we distinguish no fibres in it, though the blood-vessels form deep and almost parallel lines on its surface; its form is usually that of a thin cylinder, formed like a ring round the optic nerve: the ring, however, is not complete; a segment of a certain length being always wanting. Sometimes, as in the *perca labrax*, it consists of two pieces, one on each side of the optic nerve: at other times it is not quite circular, but presents an irregular curvature; this takes place in the *salmon*, in the *moon-fish* (*tetraodon-mola*,) and in the *cod*. But in *carps*, and most other fishes, its figure is nearly circular.

Those who are of opinion that the eye changes its figure according to the distances of the objects that are viewed, suppose that the body we have described is a muscle, intended to produce that effect, by contracting the choroides; but it would appear, that the numerous vessels which pass through it, ought to make us rather regard it as a gland, destined to secrete some of the humours of the eye. These vessels are white, fine, much twisted, and appear to pass through the

Ruyf-

Ruyfchiana; they may be seen very distinctly in the *moon-fish*, and the *labrax*. In the *cod* they are exceedingly large; they anastomose together, and are all covered by a white and opaque mucus.

Haller described these vessels as a third or intermediate lamina of the choroides, which he named the *vascular*: the glandular body itself receives a number of vessels and nerves, which are branches of the ophthalmic nerve, the trunk of which proceeds for some time in a sheath, which is common to it and the optic nerve; its own sheath opening into that of the latter, as a small vein into a larger one.

This gland does not exist in the *Chondropterygii*, as the *rays* and *sharks*, the eye of which approaches nearer to that of the *Mammalia*, as we have already shewn, with respect to the *tapetum* and ciliary processes. The choroides of these two genera consists, as usual, of a triple texture of vessels, which has some thickness and consistency. The Ruyfchiana is very thin and transparent; between the two there is a layer of silvery matter.

The *sepia*, which have several glandular bodies between their sclerotica and their choroides, have none between the latter and the Ruyfchiana; the separation of these two membranes is even sometimes difficult: the choroides is more thick, soft, and vascular; the Ruyfchiana is thin and dry; there is no tapetum; all the eye is lined internally by a deep purple varnish.

ARTICLE VII.

Of the Iris and Pupil, and of their Motions.

WE have already shewn, in the preceding Article, that the *uvea*, or that production of the choroides which forms an annular veil or diaphragm before the crystalline, is covered on its anterior surface by a particular substance named the *iris*.

A. *Structure of the Iris.*

The *iris* is a half-fibrous, half-spungy body, united in the most intimate manner to the uvea, from which it cannot be separated without a great deal of trouble, and in the largest animals. It is thickest and most loose at its greatest circumference, towards the ciliary ligament, where it seems to terminate; it is there most easily separated; but towards the edges of the pupil it becomes gradually thinner, and cannot be distinguished from the uvea.

When the long ciliary arteries arrive at the great circumference of the iris, they are bifurcated, and form a circle around it: the arteries which belong to the iris, proceed from this circle; they are numerous and radiated, and anastomose together to form a second smaller circle.

It receives a great number of small ramifications

tions from the ciliary nerves, which, after having perforated the sclerotica, and passed round the choroides longitudinally, like ribbons, but without penetrating it, are lost in the iris.

The striæ, which we remark on the iris of man, are distinguished by their colour, rather than by their elevations; they resemble little rays of light, which converge as they proceed towards the pupil: on the edge of this hole there is a circle, which is narrower and deeper than the external circle: these lines, which are straight when the iris is dilated, and the pupil contracted, are curved when the contrary disposition takes place.

It is well known that the total colour of the iris varies in different men, from blue to yellow, and to deep orange. Some domestic animals also present varieties in the colour of their eyes, as horses, dogs, &c.; but wild animals have, generally, a fixed colour for each species.

In the Mammalia this colour is frequently a deep chocolate or brown; they have fewer coloured striæ than man. In those in which the pupil is not round, we frequently observe unequal folds, which are occasioned by the motions of the iris.

Birds have the iris generally of a smooth surface, and a dark colour; it varies, however, greatly in different species, and is frequently very lively, as bright yellow, bright red, sky blue, &c.; its texture appears, by the microscope,

scope, to consist of meshes, formed by the decussation of a multitude of very fine fibres. The membrane of the uvea is so fine in birds, that when the varnish is wiped off, it is completely transparent, and the iris appears of the same colour on both sides.

In fishes, on the contrary, the iris is so fine a membrane, that we see the uvea through it, which, by its golden and silvery brilliancy, shews at first sight that it is a continuation of the choroides, which is of the nature we have already stated.

The iris of reptiles resembles that of fishes in its golden colours, but the vessels are more visible; they form a beautiful net-work on the iris of the *crocodile*.

B. *Fibres of the Uvea.*

The posterior surface of the uvea presents some compact striæ, which are continued with the ciliary processes; these striæ, though little apparent in man, are of a considerable size in the large Ruminantia, particularly in the *ox*, which has them more conspicuous than the *horse*, though the eye of the former is smaller; they are still larger in the *whale*.

The *rhinoceros* has them also very large, and extended almost to the edge of the pupil. In other genera they leave a smooth space towards that edge. In general, these striæ do not appear

pear either in birds or fishes ; we observe, however, vestiges of them in the eyes of the large *sharks*, as the *tope*, *white shark*, &c.

These fibres were long regarded as muscular ; they are now understood to be simple folds of the membrane.

C. *Motions of the Iris.*

The use of the iris is to guard against the admission of too many rays from one point into the eye, and to prevent too great intensity of light from producing a painful sensation in the retina. For this purpose, when the objects we look at are very luminous, the iris dilates, and the pupil is contracted ; but when these objects are obscure, the contrary motion takes place. As the cone of rays has its apex at the luminous point, and its base at the pupil, that base is consequently larger, in proportion as the rays it contains are less approximated ; but the absolute quantity of the rays remains nearly the same, unless the differences in the intensity of light be very considerable.

The motion of the iris is usually involuntary ; it depends merely on the rays which strike the retina. Light falling on the iris itself, causes no motion ; that membrane is not irritable, and as it has no immediate connection with the retina, the cause of their sympathy can only be sought for in the brain : when one eye receives the

light, it alone contracts: in sleep the pupil is diminished, and the iris dilated. In some cases great attention to the examination of certain objects, or a sudden fright, produce motions in the iris, independent of any change in the intensity of light.

The motion of the iris is, however, completely voluntary in some animals. The *parrot* has long been known to possess this power; it is entirely wanting, or at least scarcely exists, in fishes.

When we regard an object very closely, our pupil is contracted; first, because the light transmitted by near objects is more abundant: secondly, because that contraction admits into the eye only the least diverging rays, and excludes a part of those which would prove too numerous to be united on the retina.

Hunter has, however, proved, that this contraction of the pupil is not sufficient to explain the facility with which the same eye sees distant and near objects, and that recourse must be had to another theory, though Haller and Sabbatier admit of no other means of resolving the problem.

D. *Figure of the Pupil.*

The form of the pupil varies in different species; when it is dilated, it is generally round; it also remains round when contracted, in man, monkeys, a number of *Sarcophaga*, and in the birds; but it approaches a vertical line in the

cat

cat genus, forming different lozenges, always more narrow, according as the light is more intense. In the *ox*, and the other Ruminantia, it is transversely oblong, and in its greatest contraction, becomes a transverse line. In the *horse* it is also transversely oblong, and its superior edge forms a convexity, which has five festoons, thicker than the rest of the margin. In the *whale* it is also transversely oblong. In the *dolphin* it approaches to the figure of a heart.

The *crocodile* has the pupil similar to that of the *cat*. It is rhomboidal in *frogs*.

The *tortoise*, the *camelion*, and common *lizards* have it round. The *gecko* has it rhomboidal.

The *ray* exhibits a very remarkable peculiarity; the superior edge of its pupil is prolonged into several narrow stripes, disposed in radii, and representing together a palm leaf; these shreds, or stripes, are gilded externally, and black internally. In their ordinary state they are folded between the superior edge of the pupil and the vitreous humours: but when we press the superior part of the eye with the finger, they unfold themselves, and cover the pupil like a window-blind. It is probable that in life they close the pupil in this manner, either at the pleasure of the animal, or in consequence of the action of intense light. The *torpedo* can completely shut its pupil by means of this veil. No other fishes, not even the *shark*, possess any thing similar to this conformation.

In the *cuttle-fish*, the pupil is in the form of a kidney.

E. *Membrana Pupillaris.*

In the human *fœtus*, before the seventh month, the pupil is closed by a very fine membrane contiguous to the uvea, from which it receives its vessels; it is torn, and afterwards completely disappears, so that no vestige of it is found in the new-born infant. This membrane is observed in the *fœtuses* of other mammalia; but it is pretended that it does not exist in birds.

ARTICLE VIII.

Of the Entry of the Optic Nerve into the Eye, and of the Origin, Nature, and Limits of the Retina.

A. *Of the Entry of the Optic Nerve.*

IN Lecture IX. we demonstrated the origin of the optic nerve; and in Lecture X. we followed it to its entrance into the eye; it is necessary that we should now describe the manner in which it penetrates that organ, and produces the retina.

1. *In Mammiferous Animals.*

When the optic nerve of mammalia reaches the sclerotica, it begins to decrease in diameter; in passing through that tunic, it forms a truncated cone, which varies in length, according to the thickness of the sclerotic. When it arrives at the choroides, it passes through it by a round hole, which is filled with a small membrane, full of minute foramina. The medullary substance, transmitted through the long canals which compose the optic nerve, seems to flow through these small holes, in order to be intimately mixed, and to form that nervous expansion which lines all the concavity of the choroides, and is named the retina.

This point of the optic nerve forms sometimes a slight projection within the eye. In the *bare* and the *rabbit*, instead of a small round and cribriform disk, the extremity of the nerve projects within the eye, and forms a kind of oval cupola, which is slightly concave in the middle, and from the edges of which the retina arises.

In the greater part of mammalia we observe whitish fibres around this point, which are somewhat more opaque than the rest of the retina, and are disposed in radii.

In the *bare* and the *rabbit* these fibres make two long pencils, one to the right, the other to the left: their fineness, and their pure white colour, enliven the brown ground of the cho-

roides, which appears through the rest of the retina, thus affording a pleasing appearance to the eye.

In man we observe, near the entry of the nerve, and almost at the point which corresponds to the axis of the eye, a small fold of the retina, which forms a slight convexity when the more external membranes are removed. In the midst of this fold there is a transparent point, which, at first sight, appears like a hole; the edges of this point are tinged with yellow, in adults, but not in the new-born infant. This peculiarity of the human eye, which had escaped the observation of all anatomists before Sæmmering, is found in no other animals except in *monkeys*. We have observed it in the *cynocephalus*, in the *white-nosed guenon*, &c. &c. In the first, the transparent part is considerably larger than in man, and of an oval form; there is sometimes a yellow spot at its side.

The *maki*, which of all mammalia approaches nearest the monkeys, has only a slight fold, without any spot or transparent point. The other species have nothing similar.

2. In Birds.

In birds, when the optic nerve has arrived at the sclerotica, it is continued obliquely in a long conic cauda, which passes into a sheath of the same shape, formed in the substance of that membrane, and directed downward, and obliquely

liquely forward. The lamina of this sheath, which is in contact with the eye, is cleft throughout its whole length, by a narrow line, which allows a passage for the substance of the nerve. This fissure also exists in the corresponding part of the choroides, and is even longer there, because the point of the nerve preserves its obliquity, after it penetrates the sclerotic. In consequence of this disposition, the optic nerve does not form a round disk within the eye, as in the mammalia, but a round, narrow, and very white line, the two edges and two extremities of which produce the retina.

But there is a still more remarkable peculiarity; it consists in a folded membrane, suspended the whole length of this white line, which some have named *marfupium nigrum*, and others the *pecten of the eye of birds*.

This membrane appears to be of the same nature as the choroides, though it nowhere adheres to it; it is very fine, very vascular, and covered with the black pigment; its vessels come from a particular branch of the ophthalmic artery, distinct from the two which belong to the choroides; they descend along the folds of the black membrane, and form tufts, which are very agreeable to the eye when injected.

This membrane penetrates directly into the interior of the vitreous body, and appears like a wedge sunk into it; it is situated in a vertical plane, directed obliquely forward: the angle

nearest the cornea, in the species in which it is very broad, and the whole of its anterior edge in those in which it is very narrow, comes very near the inferior edge of the capsule of the crystalline; in some species it is applied so closely to the capsule, that it is difficult to determine whether it is not attached to it. Such is the case in the *vulture*, the *stork*, and the *turkey*, according to Petit, &c. But there are other birds in which it remains at some distance, and appears attached to some of the numerous laminae which divide the vitreous body into cells.

In the *stork*, the *heron*, and the *turkey*, this membrane is broader in the direction parallel to the cauda of the optic nerve, than in the contrary direction. In the *ostrich*, the *cassowary*, and the *horn-owl* it has opposite dimensions. It is folded like a ruffle in the direction perpendicular to the cauda of the optic nerve; the folds are rounded in most species. In the *ostrich* and the *cassowary* they are compressed, sharp-edged, and so high in the direction perpendicular to the plane of the membrane, that at first sight it has the appearance of a conical purse, rather than that of a single membrane. It was from these two species that the first academicians of Paris, who discovered it, named it the *black purse*. The folds vary as to number: there are sixteen in the *stork*, ten or twelve in the *duck* and the *vulture*, fifteen in the *ostrich*, and seven in the *great horn-owl*.

It

It is difficult to form an opinion of the real use of this membrane. From its position, a part of the rays transmitted by objects situated laterally with respect to the bird, may fall upon it. Petit conjectured that it absorbed these rays, and prevented them from injuring the distinct vision of objects situated anteriorly: others have supposed, and this opinion has lately been repeated by Home, that it possesses a muscular power, and that its use is to approximate the crystalline to the retina, when the bird wishes to shorten its axis of vision, in order to obtain a better view of distant objects. We however do not observe any fleshy fibre in it, and the experiments, which prove that it contracts after death, are not entirely conclusive. Besides, as it is attached to the crystalline laterally, it could only move it obliquely. Haller considers it as a simple support of the vessels intended for the capsule of the crystalline.

3. *In Reptiles and Fishes.*

In all reptiles the optic nerve passes through the membranes of the eye directly, and by a round hole, as in quadrupeds; it forms internally a small tubercle, from the edges of which the retina proceeds.

It is similar in a great number of fishes, as in the *ray*, in which the tubercle is papillated, in the *shark*, all the *carps*, and a number of others. The radiating fibres, which arise from

the edges of this disk, are even more apparent in this class than in most quadrupeds; but there is a certain number of fishes, in which the formation of the retina resembles, in some respects, that which takes place in birds.

I cannot yet name all the genera in which this arrangement may be found. I have observed it in *salmon* and *trouts*, in *berrings*, *mackrel*, *perches*, the *cod*, the *zeus faber*, and in the *moon-fish*; it probably exists in a number of others. It is formed thus: the optic nerve really perforates the membranes through a round hole, but after having traversed the Ruyfchiana, it forms two long white caudæ, which follow the contour of that membrane; these caudæ, though parallel, are not contiguous; a production of the Ruyfchiana passes between them, in order to penetrate into the vitreous body. The retina is produced from the opposite edges of these caudæ of the nerve, in the same manner as it arises in birds, from the single white line. The production of the Ruyfchiana has a triangular curvilinear form, and Haller has compared it to a bell; it is black, vascular like the rest of the membrane, and attached, by its extremity, to one side of the capsule of the crystalline, precisely in the same manner as the pecten of the eye of birds. It also appears to furnish blood-vessels to that capsule.

4. *In the Sepiæ.*

In *cuttle-fishes*, after the numerous optic filaments have perforated the choroides, they are confounded in a single membrane, which is the retina.

B. *Of the Retina.*

This membrane has, perhaps, the least consistency of any in the animal body; it is semi-transparent, soft, and liable to tear by its own weight; but it becomes a little harder, and more opaque, in spirits of wine; it is merely applied to the choroides, without adhering to any part of it.

In all animals that have ciliary processes, it terminates around, and at the root of these processes, where it is distinctly intersected. In birds it even forms a kind of roll or burr at that part.

It may be supposed that it is more intimately attached to the anterior surface of the vitreous body, and that it is this adhesion which occasions it to break at that place, on raising that body. The impression which the ciliary processes leave on the same surface, favours this opinion, and some have gone so far as to believe that the retina even covers the anterior part of the crystalline: they doubtless suppose that this portion of the retina remains adherent in the furrows which these processes produce
on

on the vitreous humour, and that it is covered by the pigment which is left there.

But, in animals which have no ciliary processes, the retina terminates suddenly towards the commencement of the uvea, and nothing prevents us from observing that the anterior surface of the vitreous body retains no portion of it.

The internal surface of the retina is intersected by numerous vessels which come from the central artery of the optic nerve; these vessels produce more consistency in the internal lamina, than in the external, which is merely pulpy. In fishes, in particular, it is easy to distinguish, and even to separate, these two laminae; the internal, which is named the *arachnoid*, presents very delicate, but very conspicuous fibres.

The retina is the most sensible part of the whole animal body, since light, which affects no other organ, causes there great pain when it is too intense: this is not astonishing, for, independent of the completely nervous nature of that membrane, the parts, which are situated before it, do not tend to diminish the impression of light, as the integuments which cover other nerves blunt their sensations; but, on the contrary, increase the effect of the luminous rays, by collecting them into a smaller space.

ARTICLE IX.

Of the Nature of the Transparent Parts of the Eye, of their proper Membranes, &c.

A. *Of the Vitreous Humour.*

THIS humour, which occupies the greatest part of the eye, is inclosed in its proper membrane, which is itself inclosed in the retina, but without adhering any-where to the latter membrane, unless, perhaps, by some vessels.

The membrane of the vitreous body, which is also named *hyaloides*, is very fine, and completely transparent. Spirit of wine does not render it opaque; its anterior surface is divided into two laminae, which closely adhere to the capsule of the crystalline. Between these membranes air may be introduced, which exhibits a circular canal with unequal inflations, called the *bullular canal* of Petit.

The interior of the vitreous body is divided into a vast number of cells, by septa, of the same nature as the external membrane, which are extended in every direction: in consequence of this disposition, the membrana hyaloidea cannot be emptied when perforated, as the vitreous humour will not flow at once from all these cells.

The vitreous humour is of an albuminous nature,

ture, like the white of an egg ; when it has remained long in spirits of wine, it sometimes becomes completely concrete. We preserve the vitreous humour of birds indurated in this manner ; at other times the vitreous humour dissolves in alcohol, and only its almost empty membranes remain. We know not the cause of this difference.

When hardened by alcohol, or by freezing, the vitreous humour is easily divided into a multitude of lenticular laminæ, which probably receive that form from the cells in which the humour is contained.

These observations are common to all the animals whose eyes we have described.

B. Of the Crystalline.

The crystalline lens is inclosed, without being attached, in a membranous capsule, which is soft and transparent, and strongly fixed in a depression of the anterior surface of the vitreous body ; this capsule appears to be a simple cell ; its anterior half is harder than the other ; it retains its transparency even more strongly than the crystalline.

The lens is harder in its centre than on its surface ; it is indurated, and becomes opaque by boiling, and by alcohol ; but the central part still retains some transparency, and assumes only a yellow colour.

In

In the large animals, the crystalline, thus prepared, is divided into an infinite number of laminæ, which are all inclosed within each other; the most internal are the most difficult of separation.

These laminæ are themselves divided into extremely fine radiated fibres, which proceed from two centres, situated at the two extremities of the axis, in the same manner as the meridians extend from the two poles of a geographical globe.

This structure is very apparent in the *ox*, the *whale*, &c.

Sometimes the crystalline divides rather in the direction of the fibres, than in that of the laminæ; it then forms sectors or quarters of the lens; this takes place in the mammalia and birds, but less so in fishes.

The crystalline of the *sepia* divides easily into two hemispheres, the limits of which are marked externally by a deep furrow; each hemisphere consists also of a number of concentric caps, composed of radiated fibres.

These fibres, which exist in all crystallines, have been, by some anatomists, regarded as muscular, and capable of varying the convexity of that lens, according to the distance of the objects the animal wishes to behold; but those eyes, from which the crystalline has been removed, have not the limits of distinct vision more confined than others.

Between

Between the crystalline and its capsule, we generally find a small quantity of a particular fluid.

In man, and the other mammalia, that capsule is nourished by an artery which comes from the optic nerve; this artery passes through the vitreous humour, which it also supplies by some branches, and forms, on the posterior surface of the capsule, a very complicated net, the branches of which extend to its anterior surface.

In birds it receives its vessels from the folded membrane, commonly called the *peelen*: these vessels arise themselves from the central artery of the optic nerve.

We believe that the crystalline lens itself receives some branches; certain anatomists have supposed that it is nourished by absorption.

C. Of the Aqueous Humour.

This is a limpid fluid, simply diffused in all that part of the eye which is before the crystalline; the greatest quantity is situated before the iris; the quantity behind that membrane has been the subject of much dispute; it is certain, however, that it is very small: it is supposed that the aqueous humour in man is somewhat lighter than distilled water, that is, as 975:1000. It emits no smell; its taste is slightly saltish; it is not rendered opaque by alcohol; it exhales
through

through the pores of the cornea, and its loss renders that membrane flat after death. These circumstances are common to all vertebral animals.

ARTICLE X.

Of the Suspension of the Globe of the Eye, and of its Muscles.

IN all red-blooded animals, the eye is situated in a cavity of the face called the orbit, the form and structure of which have been described in different Articles of Lecture VIII. The eye, being capable of various degrees of motion, is supported in different ways.

The orbit is most commonly conical or oblong, and a space is, therefore, left posteriorly, unoccupied by the globe of the eye.

In all warm-blooded animals, this space is filled with fat; it forms a kind of cushion, on which the globe rests and moves without being injured: the sinking of the eye in the orbit of old people, is occasioned by the diminution of this fat.

The orbit of birds being proportionally less deep than that of mammalia, the fat behind their eye is smaller in quantity; on which ac-

count, there is but little motion perceived in the eye of birds.

The *rays* and *sharks* have a particular disposition; their eye is joined to the extremity of a cartilaginous stalk, which is itself articulated in the bottom of the orbit. In this manner, the muscles act on a long lever, and have therefore great power in moving the eye.

In other fishes the eye reposes on a mass, more or less extensive, of gelatinous matter, contained in a loose cellular texture: this trembling elastic mass affords the eye a point of support in all its motions.

The *sepia* having a conical sclerotic attached to the bottom of the orbit, it is not between it and the orbit, but between it and the choroides, that the glandular bodies, which serve to support the globe, are situated. The part fixed to the edges of the optic hole, is pointed; it preserves, therefore, some degree of mobility.

The muscles of the eye, in man, are six in number: four are straight; these are attached to the borders of the optic foramen, and inserted into the anterior part of the globe of the eye, as far as the edge of the cornea, where they increase the thickness of the sclerotic.

The other two are oblique. The *obliquus superior*, or *trochlearis*, arises also from the bottom of the orbit; it sends its tendon into a cartilaginous pulley, situated near the vault of that cavity,

cavity, and proceeds upward, backward, and outward, to its insertion on the sclerotic, under the rectus externus, or abductor. The *obliquus inferior* arises from the internal part of the orbit, and passes under the eye, into which it is inserted, on the external side.

Monkeys have the same muscles as man; but the other mammalia have at least one more.

This is called the *suspensory*, or *choanoid muscle*, that is to say, in the form of a tunnel. In the Ruminantia and the horse it really forms a tunnel, or elongated cone, the point of which is attached at the optic foramen, and the extended part is inserted in the whole of the interval between the four straight muscles, a little posterior to their insertion. Several species, as most of the Sarcophaga and Cetacea, have this muscle divided into four, so that they have eight musculi recti.

In the *rhinoceros* it is only divided into two.

The oblique muscles present no variety in mammiferous animals.

Birds and fishes have, in all, only six muscles; four straight, which arise, as in man, from the edges of the optic foramen; and two oblique, both of which come from the anterior parietes of the orbit: they are attached very near each other; and one is inserted above, and the other below the globe of the eye; but the superior does not pass through a pulley, as in the mammalia.

In birds, all these muscles are attached to the soft part of the sclerotic, and we cannot follow their tendons to its osseous part, without lacerating them; they are, in proportion, much shorter than in the other classes.

In the *tortoise* we find the six common muscles disposed like those of fishes, and besides, four small ones, which closely embrace the optic nerve, and spread over the convex portion of the sclerotic, after being interrupted by the muscle of the third eye-lid, of which we shall speak hereafter.

The disposition is precisely similar in the *crocodile*.

In *frogs* and *toads* there is a great tunnel-like muscle, which embraces the optic nerve, and is divided into three portions; its inferior fibres advance more towards the edge of the eye than its superior. There is only a single straight muscle on the inferior part, and consequently only one depressor. There is one very short oblique muscle, which is attached to the anterior part of the orbit, and inserted directly into the adjoining part of the globe. The muscle of the third eye-lid is so close to the inferior part of the choanoides, that it becomes stretched when the latter swells; this accounts for the elevation of the third eye-lid, when the eye is lowered, as we shall soon explain more fully.

The eye of the *cuttle-fish* has only two small muscles,

mufcles, one fuperior, and one anterior; the head being fupposed upward.

ARTICLE XI.

Of the Eye-lids and their Motions.

THE eye-lids are membranous veils, formed by the folds of the fkin; they cover the eye in a ftate of repofe, and cleanfe its furface by their motions; by fuddenly clofing, they prevent the entrance of fmall bodies which might irritate the eye, and even, in certain cafes, affift vifion, by diminifhing the too great influx of luminous rays.

A. *In Man.*

Man has only two eye-lids, the commiffure of which is tranfverfe; their fubftance is compofed of mufcles, and a compact cellular texture, which fome have regarded as a ligament. The furface next the eye is very fine, and contains numerous veffels; the external furface is fimilar to the reft of the fkin; the edge of each is ftrengthened by a cartilage, called *tarsus*, which extends from one end of the commiffure to the other; it is rounded, and produces, with the oppofite *tarsus*, a conduit, on the fide next

the eye, by which the tears flow towards the nose; these edges of the eye-lids are, besides, furnished with a row of hairs, called *cilia*, or *eye-lashes*.

The eye-lids of man have only two muscles, the *orbicularis palpebrarum*, which closes them, and the *levator palpebræ superioris*, which raises the upper eye-lid; the inferior is lowered by its own elasticity. The *orbicularis* surrounds the eye-lid with concentric and circular fibres, which are attached to the internal or nasal angle, where there are some other fibres which have a transverse direction.

The *levator palpebræ superioris* arises from the bottom of the orbit, above the *musculi recti*, and spreads in the substance of the superior eye-lid.

In the internal angle of the eye-lids there is a small fold, in the form of a crescent, which is only apparent when the eye is turned from the side of the nose. This is a rudiment of the third eye-lid, which is developed in other animals.

B. In other Mammiferous Animals.

Monkeys do not differ from man, in respect to the eye-lids.

In the quadrupeds, the third eye-lid becomes more and more considerable, though it has no proper muscle, and cannot completely cover the
eye;

eye; it is usually semi-lunar, as we observe it in the Ruminantia, the Edentata, and the Pachydermata.

The *rhinoceros* has it thick and fleshy. In the *bare* its loose edge is convex. It is the same in *rats*, *agoutis*, &c.

In almost all species we remark a row of pores, which doubtless afford a passage for some unctuous humour; a part of its body is frequently occupied by a cartilaginous lamina; this part is named *unguis* by hippotomists. The *bare* has it triangular, and very large.

In some mammalia, besides the ordinary muscles of the two eye-lids, we observe two strata of fibres, which proceed from the *panniculus carnosus*, one of which serves to depress the inferior eye-lid, and the other to raise the superior.

The Cetacea have their eye-lids so much thickened by the oily fat situated between the two laminae, that they are almost immovable; they have no cilia, nor any vestige of the third eye-lid.

C. In Birds.

Birds have three eye-lids. The two common eye-lids have the commissure horizontal; the third eye-lid is vertical, and situated in the nasal angle of the eye; it can cover that organ entirely like a curtain. The two first contain, between their external skin and the internal, or

conjunctiva, a ligamentous membrane, which is continued into the orbit, and lines the whole of that cavity. It is particularly the inferior eye-lid which covers the eye by elevation; it is larger than the superior, and much thicker; its internal surface presents an oval plate, almost cartilaginous, and perfectly smooth. The orbicularis palpebrarum passes under this plate, but in the superior eye-lid it immediately touches the edge. The levator palpebræ superioris is only inserted towards the external angle; its origin is at the roof of the orbit: the inferior eye-lid has a particular depressor, which arises from the bottom of the orbit; there is no cartilage at the edge of these eye-lids, and only a small number of birds have cilia: indeed, these are rather feathers, with short barbs, than real cilia; these feathers are remarkable in the *horn-bill*.

Very few birds have the superior eye-lids capable of being depressed, as much as the inferior can be raised. Among others, in which, however, this may be observed, are the *owls* and the *goat-suckers*.

The third eye-lid, or *membrana nictitans*, has a certain degree of transparency; for birds sometimes look at objects through it; and by it the *eagle* is enabled to look at the sun. It contains no muscle internally; and this renders the singular apparatus which moves it necessary.

Two muscles have their fixed attachments in
the

the globe of the eye, at the posterior part of the sclerotica; one, called *musculus quadratus palpebræ tertiæ*, is fixed towards the upper and back part of the eye; its fibres descend towards the optic nerve, and terminate in a tendon of a singular nature; it is no where inserted, but forms a cylindrical canal, which bends a little round the optic nerve, crossing the direction of the fibres of the muscle. The second muscle, called *pyramidalis*, is fixed towards the side and posterior part of the globe, which is next the nose a little inferiorly; its fibres are collected into a tendon, which forms a long cord, and which passes through the canal of the preceding muscle, as if it were the neck of a pulley: having thus described more than a semi-circle, it proceeds in a cellular sheath of the sclerotic, below the eye, to the inferior part of the free edge of the third eye-lid, into which it is inserted.

It will be easily understood, that the united action of these two muscles must pull very forcibly this tendinous cord, and thus draw the third eye-lid over the eye; it returns into the angle of the two other eye-lids by its own elasticity.

D. In Reptiles.

Reptiles vary singularly with respect to the number and disposition of their eye-lids: *serpents* have none: *crocodiles* and *tortoises* have three, and the third is vertical, as in birds: there

there are also three in *frogs*, but the third is horizontal like the other two.

The horizontal eye-lids of *crocodiles* and *tortoises* close exactly; they have each an enlargement at their edge, but no cilia; their third eye-lid is semi-transparent; it moves from behind forwards, and may cover the whole eye; it has only one muscle, which is analogous to the pyramidalis of birds; it is fixed in the same manner to the posterior part of the globe inferiorly. After having turned round the optic nerve, it re-passes under the eye, to send its tendon to that eye-lid; but there are neither the musculus quadratus, nor its sheath, as in birds.

In the other lizards there are also very remarkable varieties.

The common *lizards* have, for eye-lids, a kind of circular veil, extended before the orbit, and perforated by a horizontal fissure, which is capable of being closed by a sphincter muscle, and opened by a levator and depressor; its inferior part has a smooth round cartilaginous disk, as in birds; there is, besides, a small internal eye-lid, but it has no proper muscle; it is entirely wanting in the *camelion*, in which animal also the slit of the eye-lids is so small, that the pupil can scarcely be observed through it. The *gecko* has no moveable eye-lid; its eye is protected by a slight margin of the skin, as in *serpents*. A similar disposition appears to prevail in the *scink*.

In

In *frogs* and *toads* the superior eye-lid is only a projection of the skin, and almost immovable; the inferior is more moveable, and has a swollen edge; but the third, which moves from below upward, is most employed by these animals; it is very transparent; it has one muscle situated transversely, behind the globe, which forms a thin tendon on each side of the eye, to be inserted into the free edge of the third eye-lid.

The *salamanders* have only two eye-lids, which are horizontal, fleshy, and little moveable; it appears that they may entirely cover the eye.

E. In *Fishes*.

In most fishes there is no moveable eye-lid; in some, as we have already observed, the skin passes before the eye, without even producing a fold. Others have only slight projections, which form a kind of eye-brows, rather than eye-lids. Most osseous fishes have, at each angle of the orbit, a vertical and immovable veil, which covers only a small part of it. This may be easily observed in the *salmon*, *mackrel*, &c.

The *moon-fish* (*Tetraodon Mola*) exhibits a peculiarity, which we have observed in no other animal; its eye may be entirely covered with an eye-lid, perforated circularly, and which may be closed by means of a real sphincter.

Five

Five muscles, disposed in radii, and attached to the bottom of the orbit, dilate the aperture.

F. *In Mollusca.*

The *sepia* and other mollusca, which have not the eyes at the extremity of their tentacula, have no eye-lid; the skin covers the eye, as in serpents and eels: but the *slugs*, the *snails*, &c. have an organization, which is far more complicated, and much better calculated for the protection of their eye.

This organ is situated at the extremity of a fleshy tube, called a *horn*, or *tentaculum*, which may be drawn completely within the head, and protruded by a motion similar to the evolution of the finger of a glove. In Vol. I. page 433, we described the muscles that draw the snail into its shell. At the external edge of each of these muscles, the particular muscle of the eye is attached; this muscle penetrates to the inside of the horn, to the extremity of which it is fixed; when it contracts, therefore, but still more when assisted by the contraction of the great muscle of the body, it draws the extremity of the horn inwardly, in a manner which resembles the turning in of a stocking. The annular fibres, which encircle the horn throughout the whole of its length, unfold the internal part by successive contractions, and thus bring
back

back the eye to its external position. In the naked snail, the retractors of the eyes are simply attached to the fleshy mass which forms the foot. In the inferior horns, or tentacula, which have no eyes, the mechanism is also the same.

ARTICLE XII.

Of the Glands that surround the Eye.

A. *In Man.*

IN animals that live in air, the anterior surface of the eye would soon become dry, and be rendered foul, by dust, were it not constantly bathed by a limpid fluid.—It would also be frequently injured by insects, and a multitude of other small bodies, were not unctuous substances deposited on the edges of the eye-lids, and between the cilia: these purposes are accomplished by the glands, with which the eye is surrounded, and which, in man, consist of three kinds—the *glandula lachrymalis*, *glandulae Meibomii*, and *caruncula lachrymalis*.

The *lachrymal gland* is situated towards the upper part of the orbit, above the superior eye-lid, a little towards the temple; it appears to be composed of whitish grains, and formed of two small lobes. It has six or seven very small
canals.

canals, which descend in the substance of the eye-lid, and open on its internal surface, a little above the cartilage which forms its margin.

The fluid, called tears, continually exudes through these minute apertures ; it is diffused over the front of the eye ; and when the eye-lids close, they press a part of it into the small triangular canal, which is formed by their edges and the globe, towards their internal or nasal angle.

The *glandulæ Meibomii* secrete a fatty matter, which anoints the edges of the eye-lids, and prevents the tears from wetting, or passing over them ; these glands are situated in the substance of both eye-lids, at their edges ; they are composed of small follicles, ranged in vertical and parallel lines ; their number exceeds thirty in the upper eye-lid, and twenty in the lower : their apertures are small round holes, which appear along the edge of each eye-lid.

When the lachrymal fluid reaches the nasal angle of the eye, it is absorbed by two small pores, called *puncta lachrymalia*, which are contained in two eminences situated at that extremity of the eye-lids. Each pore leads into a small canal, and both canals into the *lachrymal sac*, which opens into the nose by the duct we already described in page 89 of this volume.

The *caruncula lachrymalis* is situated in the internal, or nasal, angle of the eye-lids, and is apparent without dissection ; it is a small, round, reddish

reddish mass, composed of seven distinct follicles, which produce a thick whitish humour. The use of this humour appears, in particular, to be the protection of the lachrymal pores, by arresting light substances which might be introduced into them.

B. *In other Mammiferous Animals.*

Quadrupeds have, in general, the same glands as man, and several of them have one more.

The lachrymal gland, properly so called, is sub-divided into two or three bodies in the Ruminantia. Some separate grains have each a very short excretory duct.

In the *bare* and the *rabbit* the lachrymal gland is very large; it extends above and below the eye, and occupies the interval between the cranium and the process, which, in these animals, sustains the eye-brow; it passes behind the eye, sinks under the zygomatic arch, comes out from the orbit, on the side of the nose, and terminates there by a considerable enlargement; it appears to me to have only a single excretory canal, which perforates the upper eye-lid towards the posterior angle.

The gland peculiar to certain species of quadrupeds, and which is wanting in man, is named *glandula Harderi*, though it was seen and described by more ancient anatomists; it is always situated in the internal or nasal angle, and secretes
a thick

a thick whitish humour, which is poured out by an orifice under the rudiment of the third eyelid. In the Ruminantia it is oblong, and of a pretty hard consistency. In the *bare* it appears to be formed of two parts, merely united by cellular substance, and each sub-divided into a great number of lobes: the superior part, which is the least, is whitish; the inferior, which is much larger, is reddish. It is large and double in the *water-rat*.

It also exists in the Sarcophaga, in the *elephant*, in the *hog*, in which it is oval, in the *sloths*, &c.

The caruncle exists in the Ruminantia, as well as in man; but in them it is formed of a greater number of follicles.

I have not been able to perceive it in the *bare*, nor in several other Rodentia.

There are also differences in the manner in which the tears flow.

The Ruminantia have the lachrymal points and ducts as in man. Some genera of that order are rendered remarkable, by the *receptacles for the tears*, or *fossæ lachrymales*; these are small cavities in the cheek, one below each eye, near its nasal angle, and communicating with that angle by a small furrow. They are found in *deer*, and in *antelopes*.

The *hog* has two lachrymal points. We also find them in the *sloths* and *ant-caters*.

In *bares*, *rabbits*, and doubtless in all the genera allied to these, there are no lachrymal points,

points, but a crescent-shaped fissure under the inferior edge of the third eye-lid, which leads into a single lachrymal duct. The edges of that fissure are furnished with cartilages. There is a small semi-lunar valve in the canal, which prevents the fluid from returning to the eye.

The Cetacea, like most animals that live constantly in water, have neither gland nor lachrymal points. We merely observe, under the upper eye-lid, some lacunæ, from which a thick mucilaginous humour flows.

C. *In Birds.*

We find, in birds, the lachrymal gland, and that of Harderus. There is no caruncula. The Harderian gland is much larger than the other, usually of an oblong form, and of a flesh colour; it is situated between the levator and adductor muscles, or sometimes, as in the *turkey*, between the adductor and the obliquus inferior: it produces a single excretory duct, which passes through the substance of the third eye-lid, and opens on its internal surface. This gland furnishes a thick yellow humour. The lachrymal gland of birds is usually very small, almost round, very red, and situated at the posterior angle; it discharges itself by two or three small but conspicuous canals, precisely at the angle of the two horizontal eye-lids.

Birds of the *duck* genus, and other swimming
 Vol. II. G G and

and wading birds, have a glandular, hard, and granulated body, which occupies all the superior part of the orbit, and turns backward, to follow the curvature of the eye. In the *tufted duck* (*anas fuligula*) it is so broad that it touches the correspondent body, above the cranium: this body appears to supply the place of the lachrymal gland; but I have not yet discovered its excretory canal.

All birds have two holes, for the passage of the tears, placed in the interior angle between the two first palpebræ and the third: they are broad, but have no cartilaginous border, being soft like the rest of the surrounding skin; they lead almost immediately into the nasal sac, situated at the base of the nose.

D. *In Reptiles.*

Reptiles vary as much with respect to their lachrymal glands, as to their eye-lids.

The *sea tortoises* have a very considerable gland at the posterior angle; it is reddish, granulated, divided into lobes, and extends under the arch which covers the temple.

In the *fresh water tortoises* we find two small blackish glands, which also exist in *toads* and *frogs*; but I have not yet accurately observed their excretory ducts.

Serpents, like fishes, have no gland in the eye.

ARTICLE XIII.

Of the Eye of Insects and Crustacea.

WHAT we have to say in this article, will relate chiefly to *compound eyes*; the simple eyes are too small for dissection.

The structure of the eye of insects is so very different from that of other animals, even the mollusca, that it would be difficult to believe it an organ of sight, had not experiments, purposely made, demonstrated its use. If we cut out, or cover with opaque matter, the eyes of the *dragon-fly*, it will strike against walls in its flight. If we cover the compound eyes of the *wasp*, it ascends perpendicularly in the air, until it completely disappears; if we cover its simple eyes also, it will not attempt to fly, but will remain perfectly immovable.

The surface of a compound eye, when viewed by the microscope, exhibits an innumerable multitude of hexagonal facets, slightly convex, and separated from one another by small furrows, which frequently contain fine hairs, more or less long.

These facets form altogether a hard and elastic membrane, which, when freed of the substances that adhere to it posteriorly, is very transparent.

Each of these small surfaces may be considered either as a cornea, or a crystalline ; for it is convex externally, and concave internally, but thicker in the middle than at the edges ; it is also the only transparent part in this singular eye.

Immediately behind this transparent membrane there is an opaque substance, which varies greatly as to colour in the different species, and which sometimes forms, even in the same eye, spots or bands of different colours. Its consistence is the same as that of the pigment of the choroides ; it entirely covers the posterior part of the transparent facets, without leaving any aperture for the passage of the light.

Behind this pigment we find some very short white filaments, in the form of hexagonal prisms, situated close to each other, like the stones of a pavement, and precisely equal in number to the facets of the cornea ; each penetrates into the hollow part of one of these facets, and is only separated from it by the pigment mentioned above. If these filaments are nervous, as in my opinion they appear to be, we may consider each as the retina of the surface, behind which it is placed : but it will always remain to be explained, how the light can act on this retina, through a coat of opaque pigment.

This multitude of filaments, perpendicular to the cornea, have behind them a membrane
which

which serves them all as a base, and which is consequently nearly parallel to the cornea: this membrane is very fine, and of a blackish colour, which is not caused by a pigment, but extends to its most intimate texture; we observe in it very fine whitish lines, which are tracheæ, and which produce still finer branches, that penetrate between the hexagonal filaments, as far as the cornea. By analogy, we may name this membrane the *choroides*.

A thin expansion of the optic nerve is applied to the posterior part of the choroides. This is a real nervous membrane, perfectly similar to the retina of red-blooded animals; it appears that the white filaments, which form the particular retinæ of the different ocular surfaces, are productions of this general retina, which perforates the membrane I have named choroides, by a multitude of small and almost imperceptible holes.

To obtain a distinct view of all these parts, it is necessary to cut off the head of an insect that has the eyes large, and dissect it posteriorly: each part will then be removed in an order the reverse of that in which I have described them.

In the *cray fishes*, in general, the eye is situated on a moveable tubercle. The extremity, which is rounded on every side, and sometimes elongated into a cone, when viewed by a glass, presents the same surfaces as the eyes of insects. When we cut this tubercle longitudinally, we

observe that the optic nerve passes through it in a cylindrical canal, which occupies the place of its axis. Arrived at the centre of the convexity of the eye, it forms a small button, which detaches very fine filaments in every direction: at a certain distance these filaments meet the choroides, which is nearly concentric with the cornea, and covers the spherical brush of the extremity of the nerve, like a hood. All the distance between the choroides and the cornea is occupied, as in insects, by white filaments, closely arranged in a perpendicular direction to each other, and which have the extremity next the cornea also coated with a black pigment.

These filaments perforate the choroides, and are continuations of those produced by the button, which terminates the optic nerve.

LECTURE THIRTEENTH.

OF THE ORGAN OF HEARING, OR, OF THE
EAR.

ARTICLE I.

Of Sound, and Hearing in general.

SOUND is the sensation we experience, when certain bodies, called *sonorous*, vibrate, and communicate their tremulous motion to the atmosphere around us, or to any other body in contact with our ear. The *ear*, being affected by this motion, transmits the impression it receives to the brain. In this manner we exercise the sense of *hearing*.

The qualities which belong to sound, may be distinguished into different kinds, independent of each other, viz.

1. *Force*, which depends upon the extent of the vibrations of the body from which the sound proceeds. The greater the vibrations, the *stronger* is the sound: the extent of the vibrations is determined by the degree of impulse which produces them.

2. *Tone*, which depends upon the *velocity* of the vibrations. The vibrations made by a sonorous body in a given time, produce a *tone* which is *high* or *acute* in proportion as these vibrations are more numerous, and *low* or *grave* in proportion as they are less numerous. The laws of this velocity, and the circumstances which determine it, are well known. All things equal it is in the inverse ratio of the length, and the direct ratio of the tension, whether that tension be the effect of external agency, or of the particular nature of the sonorous body itself.

3. *Resonance*, which arises out of the intimate composition of the sonorous body: in it we distinguish different tones, as the *clear*, the *soft*, the *dull*, the *crackling*, &c. &c. with the laws of which we are not yet acquainted.

4. *Simple modulations of voice*, the different kinds of which are expressed by the letters called vowels, *a, e, i, o, u, ai, ou, eu*, &c. We are completely ignorant of the real nature of these modifications of sound, though we are pretty well acquainted with the motions which man and other animals give to their vocal organs in producing them.

5. *Articulations*, the different kinds of which are expressed by the consonants, *b, c, d*, &c. We know as little of them, as we do of the *vowel sounds*. The imitations of either of these modifications of sound, which we produce by our instruments, are, therefore, very imperfect.

The human ear can distinguish all these different qualities with relation to one sound: this distinction is made with wonderful accuracy, by persons who frequently exercise that faculty, and particularly by professional musicians. The other mammalia exhibit proofs that they are capable of distinguishing the qualities of sound which relate to speech, that is to say, *simple vocal modulations* and *articulations*; for we may observe daily, that they remember the sound and signification of several words. Some are strongly affected by certain sounds. Acute tones produce a painful sensation in *dogs*, and we also observe that these animals are terrified by violent noises: they therefore distinguish these two properties. Birds have a feeling, no less exquisite, of *voice*, *tone*, *articulation*, and even *resonance*, since they learn to sing with great correctness, and, when their vocal organs permit them, can completely counterfeit the human speech, with all the modifications practised by the individuals they imitate.

As to cold-blooded animals, it is well known that several of them call each other by certain sounds, and that others, which are incapable of producing sounds, can at least understand them, as *carps*, which appear when the noise of a bell indicates to them that they are to be fed, &c. &c.: but we know not what qualities of sound they distinguish, and how far, in this respect, the delicacy of their sense of hearing extends.

We

We are still more ignorant respecting the state of this sense in the white-blooded animals. It is evident, however, that several of them are not destitute of the faculty of hearing.

It would be of importance to determine the limits within which the ear of each animal perceives each of the qualities of sound. Thus, with respect to *force*, sounds, which are so weak as to be lost to the human ear, are distinctly heard by certain animals. Other animals also may, perhaps, endure sounds which would deafen us. With regard to tones, some are too grave, and others too acute for the human ear. Musicians have even fixed the limits of these tones at two numbers of vibrations, which are to each other in the ratio of 1 : 1024: perhaps these limits are not the same in all animals. There are great differences between the individuals of the human species, with respect to the faculty of distinguishing two very proximate tones. The difference is, perhaps, still greater between one animal and another.

With regard to *modulation* and *articulation*, the people of one country distinguish, in their pronunciation, certain letters, between which those of another perceive no difference. The same observation applies to the other qualities.

It also appears, that an ear of similar structure is not equally perfect with respect to all the different qualities of sound: one ear may be found to possess great delicacy of hearing,

as to the weakest sounds, and yet be altogether incapable of discriminating between different tones; on the contrary, a very fine musical ear may be deaf to other low sounds: if such differences are observed between one man and another, we may reasonably conclude that they exist in a far greater degree in the various kinds of animals.

It is evident that there must take place in the ear, at the moment of hearing, some change which corresponds to each of the qualities of sound we distinguish; but far from being acquainted with its nature, we are even still ignorant of the requisites, on the existence of which, *general hearing*, or the *simple perception of sound*, depends.

This consideration suggests to us the advantages that may be derived from Comparative Anatomy. It is natural to suppose that the parts, which are constantly found in all animals that hear, are those absolutely necessary to the mere perception of sound in general; and that those parts must have a more particular relation to certain qualities of sound, which are found more developed in the animals that perceive more perfectly these qualities.

But this is the point which presents the chief difficulty, because it is almost impossible for us to ascertain the kind and degree of the perceptions of other animals.

As to the parts essential to hearing, the examination

mination we are about to make, of the organs of that sense, in all the animals in which it has been discovered, will shew that the only part constantly existing is a gelatinous pulp, which is covered by a fine and elastic membrane, and in which the last ramifications of the auditory nerve are lost: this pulp fills the labyrinth in all species from man to the cuttle-fish. The organs of hearing of those animals which are placed below the cuttle-fish in the scale of being, are not yet known, though several of them afford manifest proofs of possessing that sense.

It is then almost demonstrated, that the seat of hearing resides in this pulp, or rather in the nervous filaments that float or are distributed in it. We may form a very natural idea of the connexion of this substance with the external movements which are the cause of sound: this quivering gelly will receive, with facility, the concussions transmitted to it by the vibration of sonorous bodies, and communicate them to the nervous filaments. Thus far may the motion of sound be traced; but the process, which is afterwards necessary to produce perception, escapes the anatomist as well as the metaphysician.

The other parts, which are not found in all ears, can only be regarded as accessory substances, calculated each in a particular manner to augment or to modify the sensation. Very plausible conjectures may be made with respect
to

to the effect of some of those parts. It appears evident, for example, that the external ear, which is so large in some quadrupeds, serves to increase sound, in the same manner as the trumpets used by persons who are deaf: it is very probable that the large cavities with ossæous parietes which surround the labyrinth in a number of animals, produce a similar effect by the resonance of their solid and elastic vaults. It is supposed that the thin and tense membrane of the tympanum, by means of the ossicula attached to it, transmits the vibrations of the external air with considerable force to the labyrinth. It is also supposed that the will produces, through the medium of the muscles which act on the ossicula, that degree of tension in this membrane, which is precisely necessary to bring it in unison with the sounds, to which we are inclined to pay particular attention.

It has been conjectured, that the spiral and decreasing lamina which divides the cochlea of quadrupeds into two scalæ, is composed of ossæous fibres; and, as these fibres must diminish in length from the base to the point of that organ, that each is fitted to receive concussions from a particular kind of tone. Formerly, the same faculty was ascribed to the ossæous rings which compose the semi-circular canals, and which were believed to diminish gradually from the two extremities of each canal to its middle.

The Eustachian tube has been regarded by
some

some as a supplementary passage for the sounds which do not reach the ear by the meatus externus; others have supposed, that it serves as a canal to carry off the superfluous humours from the cavity of the tympanum, &c.

The investigations, to which we are about to proceed, may perhaps throw some light upon these interesting questions.

ARTICLE II.

Of the different Forms of the Membrane which contains the Auditory Pulp, or of the Membranous Labyrinth.

THE membrane which incloses the auditory pulp is transparent, fine, and peculiarly elastic: with respect to its form, it may be regarded as self sustained, as it preserves its shape, independent of the assistance of the parts which surround it. It is, however, finer and weaker in the animals in which it is closely encircled by the bones, and particularly in man, and the other mammalia. In young animals it is more thick, more humid, and more easily separated from the bones, than in the old.

A. *In Cray-fish.*

The membrane in these animals scarcely merits the name of labyrinth; it resembles a small purse, enclosed in a scaly cylinder, open at both ends. The extremity by which this small cylinder joins the base of the antenna, affords a passage for the nerves into the purse. The opposite extremity is closed by an elastic membrane, which may be named *tympanum*, or, with more propriety, *fenestra ovalis*.

The air, or water, in which the animal lives, acts immediately on this membrane: the external appearance of this part is readily discovered, by looking at the inferior surface of the base of the large antennæ.

Fabricius and Scarpa have described it in detail.

B. *In the Sepiæ,*

The ear is almost as simple as in *cray-fish*; but it is entirely concealed in the body of the annular cartilage, which serves as the base of the great tentacula, or feet of these animals.

The membrane of the labyrinth is also a simple purse, of an oval or roundish form. In the *common cuttle-fish* (*sepia officinalis*) it has internally several conical eminences, disposed in an irregular manner: these eminences are wanting in the other species. In the pulp which fills

the membrane, there is a small body suspended, which is osseous in the *cuttle-fish*, properly so called, and similar to starch in the *octopus*.

In the *sepia officinalis*, it resembles a small valve of a concha.

C. *In Fishes that have free Branchiæ,*

The membranous labyrinth begins to assume a more complicated form. It is uniformly composed of three semi-circular canals, the dimensions of which vary, but which all communicate with a sac, more or less divided by contractions. Besides the common pulp, this sac contains one, two, or three small bones, according to the species. In the osseous fishes these bones are as hard as stone. They are always suspended in the midst of the pulp, by a great number of nervous fibrillæ. Each of the three semi-circular canals has an enlargement, in the form of a bubble, near the place where it penetrates the sac, and two are united at one of their extremities: in consequence of this junction, the canals communicate with the sac, by five apertures only, instead of six which would have existed had the union not taken place.

All the circumstances we have pointed out respecting these three canals, also exist in the superior classes; the whole apparatus is situated in the sides of the cavity of the cranium, and
fixed

sed there by a cellular tissue, consisting of vessels and osseous or cartilaginous fræna.

Fishes differ from each other in the form and proportion of the parts of the labyrinth, and those of the petrous ossicula it contains.

One of the three canals is directed obliquely forward and outward, in a plane which is nearly vertical; another is directed backward and outward, also in a vertical plane; the third is almost horizontal, and external to the other two: the two extremities, which join, and open into the sac by one aperture, are the posterior extremity of the first, and the anterior of the second canal: their other two extremities, and the two belonging to the third canal, enter separately.

The enlargement of the two first canals takes place near the extremities, which do not unite. In the third, it is at the anterior termination.

There are some obvious differences in the proportional length of the canals to the dimensions of the sac; but in general they are shorter in the osseous than in the cartilaginous fishes.

The *moon-fish*, the *frog-fish*, and the *sturgeon*, have them very long and slender. In the osseous fishes, the *pike* and the *tunny* have them longer than the *carps*, *eels*, *salmon*, &c.

The sac presents more varieties than the semi-circular canals.

In the *moon-fish* it is a simple cone, the point of which is directed towards the brain, and the

base enlarged, to receive the three canals. In the *sturgeon*, it is a broad, flat, and vertical disk, which is situated on the lateral and internal parietes of the cranium, and which also immediately receives the three canals. In the *frog-fish*, it is also a simple sac. It appears, therefore, that an undivided sac is a general character of all the cartilaginous fishes with free branchiæ; but in most of the other fishes, the part which receives the canals, and which we shall name the *sinus*, is separated by a contraction from the other part, which we shall more particularly call the *sac*.

The sinus is usually slender, and elongated from before backward: the sac is oval, and is so situated on the base of the cranium as to be frequently found very near that of the other ear; sometimes it lies in a depression of the base of the cranium.

The *pike* has a small hollow appendix, which is connected with the posterior part of the sinus, by a very small canal, and fixed, by its other extremity, to the cranium, near the edge of the occipital foramen: this appendix may be regarded as a third division of the sac, and has only, as yet, been observed in this fish.

In the *moon-fish*, the sac contains no ossicula; but, instead of them, we find some lumps, the substance of which is more of a mucous than of a cretaceous nature. In the *sturgeon* there is
only

only a single triangular ossiculum, the hard nucleus of which is partly surrounded by cretaceous matter.

In the osseous fishes, and even in some of the cartilaginous kind, as the *frog-fish*, there are always three ossicula: two of these are in the sac, viz. the largest, and a small one behind it; the third is also very small, and is situated in the common sinus of the canals.

The form of the bones, and their mode of adhesion to the sac, deserve to be noticed, particularly with respect to the largest.

It is commonly oblong from before backward, situated obliquely in the sac, convex on its internal surface, and concave on its external.

The internal surface is smooth, but marked with a furrow, which varies according to the species. The external surface has some asperities. The superior margin is usually denticulated in a more conspicuous manner than the inferior, and the anterior extremity has frequently some tubercles or projections; there are two of these in the ossiculum of the *pike*, the *mackrel*, and the *herring*; three on that of the *carp*, which has the middle one in the form of a style. In the *cod*, and other *gadi*, the *roach*, the *labrus*, &c. the anterior extremity is rounded, and has no points.

The proportional size of this bone varies considerably; it is small in the *eel*, the *star-gazer*, the *pleuronectes*, the *dory*, and the *pike*. Of a
 H H 2 middling

middling size in the *berring*; and large in the genus *gadus*, (particularly in the *cod*,) in the *carp*, and a number of the thoracici.

Its general form is oval in the *cod*, and most of the *gadi*; it is almost round, with an inward angle in the genus *cyprinus*, as the *carp*, the *bream*, the *tench*, the *roach*, and also in the genus *silurus*. In the *pike*, the *salmon*, and other *trouts*, and in the *sturgeon*, &c. it is irregularly triangular.

The furrow on the internal surface of the bone appears to form, with an internal production of the membrane of the sac, a small canal, which passes through a part of the interior of the same sac: this furrow is commonly longitudinal; sometimes it is shaped like a horse-shoe; it is almost circular in the *carp*. In the *cod*, its place is supplied by an elevated ridge.

Some transverse striæ are almost always observed to extend from the furrow to the edge; they are intended to lodge the numerous nervous filaments which suspend the bone: these striæ are more particularly conspicuous in the *carps*, which have them radiated.

The denticulations on the edge of the bone are nearly equal all round in the *cod*, and in the *carp*, but the former has them blunt, and the latter pointed; they are found on one side only in the *salmon*, *trouts*, and *perches*. The *congreel* has only three, which are on the superior margin, &c.

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The second ossiculum of the internal ear of fishes is usually situated behind the large bone, but a little more outwardly ; it is most commonly of a semi-lunar form, the concave part being turned forward ; it is of a particular shape in the *carp*, similar to the head of a spear ; its size varies, but it is always much smaller than the first.

The third ossiculum, we have already observed, is within the sinus ; sometimes it is so near the largest of the bones, that it can scarcely be distinguished at first sight. In the genera *gadus*, *scomber*, &c. it is triangular ; in the *trigla*, lenticular. The *pike* has it rounded, and unequal. It is proportionally larger in the *carp*, than in the other genera, and its surface is scabrous, and the edge ferrated.

Casserius, who first described the organ of hearing in fishes, considered these bones as analogous to the *malleus*, *incus*, &c. of quadrupeds.

It has since been conjectured, and Camper, in particular, has shewn, that substances thus suspended, in a tremulous gelly, which is calculated to be put in motion by the slightest external vibrations, may communicate the concussions to the numerous filaments of the auditory nerve, to which they are connected.

A septum is formed within the sac, by means of its internal membranes, united with these ossicula, and their nervous fibres : this structure induces us to consider the sacs as analogous to

the organ, with two apartments, which is, in man, called, from its form, the cochlea.

D. *In Fishes that have fixed Branchiæ,*

We find the same parts as in the other species, but they are differently disposed. The situation of the sac is nearly horizontal, and its figure is triangular. The angle which is nearest the brain, is prolonged in a canal which penetrates the cranium, and extends to the external skin, where it is closed by only a thin membrane: this small membrane may be distinguished without dissection, because it forms a small external depression near the nucha; it is, perhaps, analogous to the fenestra ovalis in animals, of a more elevated order, and performs also the functions of the tympanum.

The second angle of the sac is posterior; it is round or oval, and contains the largest of the cretaceous substances. The third angle is directed forward and outward, and the two small cretaceous bodies are situated near it.

There are three semi-circular canals, each of which has a bullular enlargement, or ampulla, as in the other fishes: one is anterior, and directed obliquely forward and outward: the second is external, and horizontal: the third is posterior, and situated in a plane, which is almost vertical, and directed backward and outward. Those extremities of the three canals,
which

which have no ampulla, communicate with the internal angle of the sac ; the first and the third near the fenestra rotunda, and the second a little lower. As to their other extremities, the first and the second unite, and communicate, by a common canal, with the external angle of the sac ; the ampullaceous extremity of the third enters the sac separately, very near the place whence its other extremity arises.

The whole of this organ is, as usual, filled with a gelatinous pulp. The solid parts contained in the sac do not resemble those of the osseous fishes, with respect to their consistence. They are not harder than moistened starch, and may be bruised by the fingers : the largest of these substances is rounded on one side, and compressed and recti-linear on the other ; the two smaller are nearly oval.

All these observations are common to the *rays* and *sharks*. The species of these two genera differ from each other only in the proportion of the canals and the sac ; but the variations thus produced are very unimportant.

E. *In Reptiles.*

The membranous labyrinth in this class is, in general, composed, as in the fishes, of three canals and a sac : but there are some species which have an additional part.

In the *salamanders*, whose ear, like that of
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fishes,

fishes, consists of the labyrinth only. The three canals are situated above the sac; they are depressed superiorly, and form together a triangle which is almost equilateral; each has its ampulla, and the sac contains a body of the consistence of starch, as in the *rays* and *sharks*.

Frogs and *toads* differ very little from *salamanders*, with respect to the membranous labyrinth; they have the same parts in the same position, and their sac also contains one amylaceous substance: their three canals form nearly a complete circle, by their junction with the sac.

Crocodiles and *lizards* have also three canals, but they are larger, and each approaches nearer to a perfect circular form: the sac is situated proportionally more within the head; its membranous parietes are furnished with several blood-vessels, which are particularly conspicuous in the *crocodile*. The solid parts it contains are three in number, and they are smaller, and even softer than those of the Chondropterygious fishes. Lastly, their labyrinth is rendered remarkable, by having an additional part to those we have already described: this is the first vestige of the cochlea; it is a production of the sac, in the form of a cone slightly arched; it is directed, under the cranium, towards the middle line, and is divided into two compartments, or rather canals, by a double cartilaginous septum: one apartment communicates with the sac; the other, which is a continuation of the first, reflected

flexed on itself, terminates at a very small hole, which is closed by a membrane that separates it from the cavity of the tympanum.

This organ is precisely similar to that which is found in all birds. Comparetti was the first who described it in *lizards*. It is very large in the *crocodile*, and may be easily prepared from young subjects.

It is more difficult to find this part in the *camelion*, and the *marbled-lizard*. A vestige of it may be observed in the *serpents*. The production which may be compared to this trumpet, or rudiment of the cochlea in the *tortoise*, is very similar to the part we named the sac, strictly so called, in fishes; and this resemblance consists not only in its form, but in the small amylaceous substances it contains: this seems to leave no doubt of the analogy between the sac and the cochlea in man, or of that between the part we called the sinus, and the vestibule. We must, therefore, judge of the perfection of the labyrinths of these different ears, by the degree in which the cochlea is developed.

Tortoises and *serpents* have the semi-circular canals, like the other reptiles. In the tortoise they are proportionally very short.

The *warm-blood animals* have the labyrinth always closely enveloped by bones; and in all the species, it is composed of three semi-circular canals, each of which has an ampulla; of a sinus common to these canals, called the vestibule;

bule; and of an organ, with two canals or scalæ, called *cochlea*, but which is not really spiral, except in the Mammalia.

F. *In Birds.*

The part corresponding to the cochlea in birds, we have already observed, resembles that of the crocodile; it is conical, slightly arched, obtuse at the point, and situated obliquely from before backward, and from without inward, under the inferior part of the cranium. The septum, which separates it into two scalæ, is composed of two narrow cartilaginous laminæ, united by a thin membrane throughout the whole of their length, and slightly twisted on themselves; they adhere weakly to the parietes of the cochlea. The posterior scala is shorter, and communicates with the cavity of the tympanum by the fenestra rotunda, which is closed by a membrane. The anterior and longer scala penetrates into the vestibule, and is not closed.

The vestibule is small, and almost round. The semi-circular canals are disposed in the following manner: the largest is vertical, and directed obliquely from behind forward, and from within outward: the second is horizontal, and directed outward: the third is vertical, crosses the second, and takes a course which is the opposite of that of the first.

In the Passeres the first canal is smallest, and
situated

situated farther back with respect to the other two, than in other birds. The other differences are not important : they appear, however, more considerable in the birds of prey, particularly the nocturnal kind ; and in the Passeres, than in the Gallinæ and the Palmipedes.

In the *casowary* and the *ostrich* the cochlea approaches more to a vertical position ; and of all birds, the *ostrich* has the smallest cochlea, in proportion to the other parts. The *goose* is the species in which it proceeds most directly towards the middle line.

G. *In Mammalia.*

The labyrinth of the mammalia does not differ from that of other animals, except that the cochlea is really formed with several spiral turns round a conical axis, and may, therefore, with propriety, be compared to the shell of a snail.

The three canals are almost equal in *man* ; they do not cross each other ; the horizontal is rather the smallest ; the anterior, or vertical canal, and the posterior, are united at one of their extremities ; each of the three has a small ampulla ; the vestibule is a little rounded ; the cochlea is situated forwards, and a little inward ; the plane of its base is almost vertical, and directed obliquely from behind forward, and from

without inward. The breadth of the base does not exceed that of the horizontal canal.

The spiral part forms two turns and a half; it diminishes rapidly, so that the cochlea approaches, upon the whole, to a globular form. As the axis is oblique, one scala is anterior and external, and the other internal and posterior. The internal, which is nearest the base of the cochlea, is a little longer than the other, and turns back, to terminate in the fenestra rotunda, which communicates with the barrel, or cavity of the tympanum. The external, which is nearer the apex, extends to the vestibulum, which is itself connected with the cavity of the tympanum by the fenestra ovalis. The relative proportions of the parts of the labyrinth vary considerably in the different species.

In *bats*, properly so called, but more particularly in the *horse-shoe bat*, the cochlea greatly exceeds the semi-circular canals in magnitude: the breadth of the cochlea in the *horse-shoe bat* is four times greater than the circumference of one of the canals, and the diameter of its cavity is ten times longer than theirs.

This disproportion is much less considerable in the *ternate bat*.

In most of the *Sarcophaga*, and in the *hog*, *elephant*, and *horse*, the cochlea is also larger, in proportion to the canals, than in man. But in the *mole* it is smaller. The *hare* has it also proportionally

portionally smaller than man. Its proportion in the Ruminantia is nearly the same as in man. In all these animals it has the shape of those shells which conchylogists call turbinated, that is, of a round or globular cone. The number of the turns is as in man, two and a half.

The *guinea pig*, the *cabiai*, and the *porcupine*, have a turriculated cochlea, with three turns and a half; these are the only examples I know of this number. The *common rat* has, like the other quadrupeds, only two and a half.

The cochlea is very large in the Cetacea, and all its parts are well developed; but the spiral part remains nearly in the same plane, without rising upon its axis; it makes, besides, only a turn and a half. The semi-circular canals are so small, that Camper long denied their existence. They are, however, in other respects, similar to those of the rest of the mammalia, and I have made a very perfect dissection of them in the fœtus of the *whale*.

The proportion between the two scalæ of the cochlea is not the same in all mammalia: that which goes to the tympanum is somewhat larger than the other in *man*, the *dog*, the *sloth*, the *elephant*, the *horse*, the *dolphin*, &c. The difference is very remarkable in the *bat*. The scalæ are nearly equal in the *hippopotamus* and the *hog*. That which communicates with the vestibulum, is the largest in the *calf*, the *goat*, the *sheep*, the
bare,

bare, the *rat*, the *guinea pig*, the *cat*, &c. But even in these animals, the part of the *scala* of the *tympanum*, which is very near the *fenestra rotunda*, widens and becomes broader than the other.

In mammiferous animals in general, the *labyrinth*, considered as a whole, is much smaller, in proportion to the rest of the head, than in birds. It contains no solid parts in these two classes; we observe only some white parts, which proceed from the expansion of the extremities of the nervous filaments, in the gelatinous pulp which fills it. Of these we shall speak hereafter.

ARTICLE III.

Of the Manner in which the Membranous Labyrinth is contained in the Bones, or of the Osseous Labyrinth.

THE membranous labyrinth of vertebral animals is more completely contained in the bones, and more closely embraced by them, in proportion as those animals are more perfect, and possess ears, with which the external element freely communicates.

A. In

A. *In Fishes that have free Branchiæ,*

The labyrinth is contained in the same cavity as the brain: the parietes of the cranium afford only some depressions for receiving it, and it is retained in these hollows by vessels and cellular substance. Only a part of the semi-circular canals is situated in pulleys, or short osseous canals.

In the *moon-fish* the large lateral depression of the cranium, which contains the ear, is divided by only two small cartilaginous columns, one of which is horizontal, and furnishes a pulley to the posterior semi-circular canal: the other is vertical, and affords one to the horizontal canal; but as the interval between these columns and the parietes of the cranium is ten times greater than the diameter of the canals, they are suspended in that space by vessels and cellular substance. The anterior vertical canal has even no column of this kind, and there is no depression for the sac in the base of the cranium.

The cartilaginous columns become broader in the *frog-fish*, and approach more to the parietes of the cranium. In the osseous fishes they are still farther enlarged, and there is constantly a certain portion of all the semi-circular canals contained in others, which are formed of bone. The posterior and horizontal canals are always more enclosed than the anterior; the
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latter has only a small osseous pillar in the *eel*, the *pike*, the *roach*, and the *mackrel*. It has merely a furrow in the *dory*, and some of the jugulares. It has an osseous canal, which is a little longer, in the *cod* and the *carp*: the other two are almost sunk in the bones. In the *salmon* and the *carp* the sac is commonly situated in a depression at the base of the cranium. In proportion as the sac is farther removed from the sinus or vestibule, the fossa, which receives it, becomes deeper. This may be observed in the *cod*, but particularly in the *carp* and the *berring*, which have the sac closely enveloped in an osseous antrum, that has no outlet, except one for the narrow canal, which joins the sac to the sinus.

In all the osseous fishes, the sinus, and the extremities of the canals, are at liberty in the cavity of the cranium, and the nerves have not to pass through bones in order to reach them.

In the *sturgeon*, the ear begins to separate from the cavity which contains the brain. The three canals are placed in cartilages, throughout the whole of their length: the cartilaginous canals, which receive them, are somewhat larger than they are; the sac, to which they are joined, is closely applied to the side of the cranium; and between it and the cavity for the brain, there is a very thick membrane, connected by several ligamentous productions, and perforated by several holes for the passage of the nerves.

B. In

B. *In the Chondropterygii,*

Or fishes that have fixed branchiæ, as the *rays* and the *sharks*, the whole of the membranous labyrinth is enclosed in a particular cavity, formed in the substance of the cranium; this cavity is situated on the side and posterior part of that which contains the brain, with which it does not communicate, except by the holes that afford passages for the nerves.

This cavity seems moulded upon the membranous labyrinth itself; it is composed, in the same manner, of three canals, and of another, with which they join. But all these parts are considerably larger than those they contain, and the latter do not adhere to the parietes of these cavities, but are suspended in them by vessels, nerves, and cellular substance. In consequence of the size of the external labyrinth, the termination of the membranous semi-circular canals are situated within the cavity which contains the sac of the amylaceous bodies. The holes, through which the nerves pass, correspond with this cavity on the internal side; externally it communicates with the hole called *fenestra ovalis*, which is closed only by a membrane, and by the skin which passes above it.

C. In Reptiles.

The osseous labyrinth of reptiles resembles that of the Chondropterygii, that is to say, it envelopes the whole of the membranous labyrinth, but in a manner more or less closely.

In the *tortoise*, the septum which separates the vestibule from the cranium, is not ossified; it remains partly membranous.

In the *crocodile*, and other *lizards*, the osseous labyrinth closely embraces the membranous, or completely covers it by a thin and hard lamina.

D. In Birds and Mammalia.

The membranous labyrinth in these classes is so completely, and so closely encased by the bones, that its nature has long been misunderstood. It has most commonly been regarded as the internal periosteum of the cavities in which it is contained. When observed in a dry state, and shrivelled up into hard filaments in these cavities, it has been described under the name of the nervous zones of the semi-circular canals, or the membranous septum of the vestibulum.

Scarpa and Comparetti have, however, assigned to this part its proper importance. Indeed, when we examine it in young and recent subjects, we find that it does not differ from
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the analogous membrane in fishes : that it is really the essential part of the labyrinth, and that the osseous cavities serve only as its case.

The osseous labyrinth of birds is formed by a thin and hard boney plate, so exactly fitted to the membranous labyrinth, that we can even distinguish in it the ampulla of the semi-circular canals : as it is situated in the substance of the temporal and occipital bones, the two tables of which are separated by only a very open diploe, which is easily removed, it may, without much trouble, be laid bare, so as to afford a view of all the parts.

Some of these parts, particularly two of the semi-circular canals, are even visible within the cranium, without any preparation. The auditory cells, of which we shall speak hereafter, and which form vacant spaces around and within the intervals of the labyrinth, render its preparation still more easy.

In mammalia, the labyrinth is usually enveloped by the substance of the pars petrosa of the os temporum, which is so dense in the adult animal, that the two parts cannot be distinguished. The cavities which compose the labyrinth, appear to be hollowed out in that petrous substance, in the same manner as quarries, or mines, are formed in rocks.

It is only in the foetus that the osseous labyrinth can be disengaged from the substance which envelopes it, and which has not then

acquired the same degree of hardness as the laminae, of which it is formed.

There are, however, some species, and they are of the number of those which hear best, that have not the petrous substance around the thin lamina of their osseous labyrinth.

In the *mole*, for example, the three semi-circular canals are disengaged, and visible on the interior of the cranium, without any preparation. The cochlea is enveloped by cellular structure, almost as lax as that of birds.

The enormous cochlea of *bats* is visible, without any preparation, under the base of the cranium, where it forms a considerable projection, similar to that made by the cavity of the tympanum, in a number of species: their semi-circular canals may be observed within the cranium, in the same manner as those of the *mole*.

In the *barc-lipped bat* (*vespertilio Leporinus*,) the cochlea projects within the cranium.

In the *guinea pig* (*cavia cabaya*,) and in the *cabiai* (*cavia capybara*,) it projects into the tympanum, under the two fenestræ, in the form of a nipple. It has the same appearance in the *marmotte* and the *porcupine*; and is more or less similar in all the Rodentia. It also projects a little within the tympanum in the *elephant*.

The Cetacea are the animals which have the substance of the pars petrosa hardest.

From the description we have given of the mem-

membranous labyrinth, it will be easily perceived, that the osseous vestibule must have five holes for the extremities of the semi-circular canals; one for the scala of the cochlea, which communicates with it; and one communicating with the cavity of the tympanum, which is the fenestra ovalis.

We shall not stop to describe the differences which occur in the size, shape, and relative position of these seven holes.

The osseous cochlea turns round a conical axis; it may be compared to the fusée of a watch; the proportions of its height and base vary according to the species. The section of each turn of the osseous cochlea is not round; there is, on each side of the axis, a sharp ridge, which is the section of the osseous part of the spiral lamina that divides all these turns into two scalæ.

In man, only that portion of the lamina which touches the axis is osseous; the other part is entirely membranous. The same structure, however, does not prevail in all mammiferous animals. In the *dolphin* there is only one very narrow fissure, which divides the lamina, throughout its whole length, into two parts; that which touches the axis being three times larger than the other. The fissure only is completed by a membrane in the fresh state.

In the *dolphin* also, the osseous part of this septum, which touches the axis, has, under its

base, and in the scala that joins the tympanum, a small canal, following the same curvature from one extremity of the cochlea to the other; the transverse section of this canal is round, and its parietes are very slender; it might be regarded as forming a third scala in the cochlea, but it is probable that it serves to envelope a vessel or a nerve; besides, its diameter diminishes in the opposite direction of that of the scalæ, and it is largest towards the apex of the cochlea. In the Ruminantia we also observe a similar canal, but proportionally much smaller.

We have sufficiently described the external form of the os petrosum of quadrupeds, in Articles III. and IV. of Lecture VIII. That of the Cetacea deserves to be considered separately; it is not articulated with the bones of the cranium, but is suspended by ligaments under a cavity, or vault, which is situated on each side of the base of the cranium, and principally formed by the os occipitis.

The os petrosum may itself be considered as formed of two portions soldered together, viz. the cavity of the tympanum, which we shall describe at the end of the next Article; and the petrous part, properly so called, which contains the labyrinth.

The superior surface of this second portion has, towards its internal edge, a semi-circular eminence, which corresponds to a hole in the base of the cranium, and where we observe a

depression, which is the internal meatus auditorius. The cochlea is situated in this eminence. The external portion of the os petrosum is considerably larger than the eminence we have just pointed out; it partly forms an arch above the cavity of the tympanum; it is oblong in the *dolphins*. In the *cachalots* it is coarsely rounded, and prolonged backward into a scabrous process. The *lamantin* has it deeply bilobated.

We shall now briefly notice the *aquæducts*. These are two canals, which form a communication between the labyrinth and the interior of the cranium, different from that which affords a passage for the nerves; one goes to the vestibulum, near the common orifice of the two united semi-circular canals; its orifice, on the side of the cranium, is triangular, and situated above and behind the meatus auditorius internus: the other arises from the cochlea, at the scala tympani, very near the fenestra rotunda, and opens into the cranium, under the inferior edge of the os petrosum, and below the internal meatus: these aquæducts are found in all the mammalia. They are very large in the *dolphin*, particularly that of the tympanum.

In some other mammiferous animals, as the *elephant* and the *horse*, the last duct forms only a narrow fissure on the side of the cranium. I have not sufficiently examined them in the other species of this class.

According to Comparetti, two analogous canals are found in birds, but their use appears to us still doubtful.

ARTICLE IV.

Of the Cavities situated between the Labyrinth and the external Element, or, Of the Cavity of the Tympanum, and its Appendages.

IN the *fishes with free branchiæ*, whether cartilaginous or boney, the labyrinth has no communication externally: all the parts of the ear are inclosed within the cranium, and covered by the bones.

In the *fishes with fixed branchiæ*, or the Chondropterygii, the labyrinth communicates by a small canal, with an aperture situated behind the head, and closed by a membrane and the skin: there is nothing besides this between the ear and the surrounding element.

Among the reptiles, the *salamander* has the labyrinth completely enclosed within the cranium, and deprived of all external communication, as in the fishes that have free branchiæ: but the other genera of the same order have all a fenestra, called *oval*, supporting an ossicous plate, analogous to the bone, called stapes in man.

man. The *lizard* genus has another aperture, but which is closed only by a membrane, and which receives the name of *fenestra rotunda*. These two apertures exist in all birds, and in all quadrupeds, as has already been shewn.

The cavity, which is situated anteriorly, and which is more or less complicated in different animals, is called the *barrel*, or *cavity of the tympanum*; it communicates with the mouth by a canal, or by a simple wide aperture, called the *Eustachian tube*: another aperture affords a communication with the external element; it is sometimes shut by a thin membrane, at other times covered with a thick, or even scaly skin; these parts are called *membrana tympani*.

The osseous plate, which covers the *fenestra ovalis*, is connected by a handle-like production of a single piece, or by a chain of ossicula, articulated with each other, and with the membrane of the tympanum, and may therefore communicate the impressions received by the latter, to the interior of the vestibulum.

The cavity of the tympanum forms the subject of description in the present Article.

A. In Reptiles.

The barrel, or cavity of the tympanum, cannot be said to exist in *serpents*: the stalk of the plate is surrounded by the flesh, and its extremity touches

touches the skin, near the articulation of the lower jaw.

In *toads* and *frogs*, the whole of its posterior part is membranous; it communicates immediately with the back of the mouth, by a large hole, which may be seen on opening the mouth of the animal. It is very small, and almost entirely membranous in the *pipa*, in which the labyrinth is connected with the fenestra ovalis by only a very long canal.

It is also membranous posteriorly and inferiorly in the common *lizards*, and in the *camelion*; it communicates with the bottom of the palate by a short wide canal.

The barrel of the *crocodile* may be divided into two parts: one external, which is very wide, and closed on the outside by the membrane of the tympanum, and the skin, but entirely surrounded by the bones; and one internal, which is separated from the former by a contraction, and which communicates with the two fenestra, and with some cavities analogous to the mastoid cells of man, but much larger: one of these cavities is placed between the semi-circular canals, and the other is directed backward and outward; the barrel is situated towards the superior part of the cranium.

The cavity of the tympanum in the *tortoise* is placed more laterally; it is not so wide externally; and the contraction, which separates the
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the external part from the internal, is less conspicuous, because the projection, which it forms, is rounded, and not acute, as in the *crocodile*. The internal portion is prolonged backward, in the form of a large round cell: in the bottom of the cavity, opposite to the membrane of the tympanum, there is a narrow canal, in which the ossiculum is sunk, and which communicates with the fenestra ovalis. The Eustachian tube is a canal of a moderate length, which proceeds downward, and a little backward, and terminates in the palate, behind and within the articulation of the jaw.

B. *In Birds.*

The cavity of the tympanum is also very wide on the outer part, in birds: its posterior and inferior parietes are formed by a projection of the os occipitis: the anterior is, in a great measure, completed by a bone peculiar to birds, called *os quadratum*. We shall describe this bone when we treat of the articulation of the lower jaw.

It communicates with three large cavities, which are more or less prolonged into the substance of the bones of the cranium, and which particularly characterize the organ of hearing in birds. These cavities, being inclosed by thin and elastic osseous lamina, are doubtless very sonorous, and considerably augment the
effect

effect of sound, with respect to the labyrinth, which they surround on all sides. In the *owl* genus, particularly in the *white owl* (*Strix flammea*), they are more extensive than in any other birds; the first opens into the superior part of the tympanum, and extends through the whole breadth of the occiput, as far as the corresponding cavity of the opposite ear, with which it unites above the foramen magnum; the second enters the barrel at its posterior and inferior part; this cavity extends only between the semicircular canals, and is the smallest of the three; the third communicates with the anterior part of the barrel of the tympanum, above the Eustachian tube: it passes above that tube, and extends through the breadth of the base of the cranium; it unites with the cavity of the other side, under the part which contains the pituitary gland: thus the barrels of the tympana, in the *white owl*, communicate by two different channels: the third cavity surrounds the part analogous to the cochlea.

This vast extent of cells, attached to the barrel of the tympanum, is found in the *white owl* only. In the other *common* and *horned owls*, the cavities are a little contracted, and they diminish more and more down to the *casſowary* and the *ostrich*, which, of all birds, have them the smallest. The *goat-sucker*, a nocturnal bird, to which a quick sense of hearing is necessary, has them very large. Diurnal birds of prey, and
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the Gallinæ, have the first cavity, and the third, in the form of a narrow conical tube, without any communication from the one side of the head to the other: the second, or that between the semi-circular canals, is larger in the diurnal birds of prey than in the owls, because they extend outward, behind the posterior edge of the barrel; these cavities are generally small in the Anseres and Grallæ. They appear to be entirely wanting in several species of *parrots*, in which the internal substance of the bones of the cranium is uniformly a very loose diploe: their tympanum, however, has a more considerable concavity posteriorly, than that of other birds.

The Eustachian tube is completely osseous in birds; it is a conical canal, which commences at the anterior and inferior part of the tympanum, by a large aperture, and which passes under the third cavity, described above, from which it is separated by only a thin lamina; it proceeds obliquely inward, contracting gradually, and terminates in a small aperture very near the middle line, and consequently also very near the tube of the other side; these two apertures open into the palate behind the internal nares.

The two fenestra, by which the labyrinth of birds communicates with the cavity of the tympanum, are situated one above the other, in a depression opposite to the *membrana tympani*; an osseous bar separates them. The fenestra

called *ovalis*, or that which communicates with the vestibulum, is above the fenestra named *rotunda*, which communicates with the cochlea; but they are both of an oval shape; the fenestra *rotunda* is the largest, and frequently exceeds the size of the other considerably.

C. In Mammalia.

The cavity of the tympanum, in mammiferous animals, presents very remarkable differences, as to dimensions, form, structure, and internal arrangement.

In *man* this cavity forms almost a hemisphere, and the membrane may be regarded as its great circle; it neither projects without nor below the cranium; its parietes are very unequal; that which is opposite to the membrane of the tympanum, has an angular elevation, which ascends obliquely from before backward, and which is named the *promontory*. The *fenestra ovalis* is above it: the longest diameter of this fenestra is transverse, and almost double the smaller; it is exactly opposite to the membrane of the tympanum: the *fenestra rotunda* is below the promontory; it is directed a little downward and backward; they are both a little sunk. There are some slight excavations in the barrel of the tympanum, which might be compared to the cells of birds, but could only be regarded as very minute vestiges of them; they are not
similar

similar in all individuals; there is one above and before the oval fenestra, and another behind the round; the latter communicates in adults with the cells, which are formed, at a certain age, within the mastoid process of the temporal bone. The Eustachian tube begins at the anterior and inferior part of the barrel, by a hole which is nearly round; it first forms an osseous canal, which is directed downward and inward, towards the point of the os petrosum, where it is narrowest; it is continued from this place as a cartilaginous canal, which is enlarged, as it advances, and terminates in the back of the mouth, near the internal pterygoid process, and consequently near the posterior orifice of the nares of the same side, by a wide aperture, like the end of a trumpet, the edge of which forms a projecting burr, or roll.

1. *External Form of the Cavity of the Tympanum in Mammalia.*

Amongst *apes*, the *guenons* and the *maggots* have not the os petrosum more prominent under the cranium than we observe it in man, and the barrel, or cavity of the tympanum, remains concealed within it: the mastoid process becomes very small, or is almost obliterated; but the mastoid cells extend farther into the rest of the temporal bone.

In the other mammiferous animals, beginning with the *sapajous*, the barrel increases considerably

ably in size, and forms a large protuberance under the cranium.

This protuberance is oval; and its great axis is longitudinal in the *sapajous*, *badgers*, *civets*, and *martins*.

It is a little rounded, and its great axis is directed obliquely inward, in *dogs*, *cats*, and *coatis*.

It is almost round in *hares* and *beavers*.

It is semi-spherical in *ternate bats* and *pangolins*.

It is more or less angular in the Ruminantia, the *cabiai*, the *stoth*, the *hippopotamus*, the *elephant*, and the *rhinoceros*.

It is plain in the *mole*, and touches that of the other side, which makes the cranium appear smooth inferiorly.

In the *ant-eaters*, the floor of the nostrils being continued between the two barrels, their projection, under the cranium, cannot be observed.

In the *bear* there is no protuberance.

In the *hog* there is a long projection, like a sac or a club, which is most contracted at the part joining the cranium.

In most of the digitated mammalia there is no mastoid process, except a slight protuberance arising from this projecting part of the barrel, or the barrel itself supplies the place of that process: but in the *cabiai*, the *guinea-pig*, *hogs*, the Ruminantia, and *herfcs*; there is, behind the tympanum, a long process, which an-
fwers

swers to the mastoid. It belongs, however, to the occipital bone.

In most of the Sarcophaga and Rodentia, the parietes which form this projection are thin, hard, and leave a large vacancy between them. In *bogs*, on the contrary, the whole of the interior is compact and cellular.

In the Carnivora and the Rodentia, the surrounding lamina which encloses the cavity of the tympanum, is distinguished from the rest of the os petrosum by a future, and is not united to it until these animals reach an advanced age.

In *cats* and *civets* it is itself subdivided into two parts by another future: the posterior portion has much resemblance to a cochlea, and, except the difference in thickness, is perfectly represented by the barrel of the *whale*.

2. *Internal Division of the Cavity of the Tympanum, and Mastoid Cells.*

The oval frame which supports the membrane of the tympanum, is almost parallel to the opposite side of the cavity; it corresponds nearly to the middle of that side in *man*, the *monkey*, the *dog*, the *badger*, *weasles*, Rodentia, Ruminantia, &c. In all these animals, the promontory corresponds to the middle or posterior part of the tympanum; but a space always remains between it and that membrane; and the parts of the barrel situated before and behind the promontory, are not separated in a marked manner.

In the *cat* and *civet* genera, however, there is an osseous process, which extends from the posterior and inferior edge of the frame of the membrana tympani, to the promontory, and which, being prolonged obliquely, divides the barrel into two unequal parts that communicate together only by a hole. The anterior and external cavity is the barrel of the tympanum, properly so called, and contains the ossicula and the fenestra ovalis. The other part, which is much larger, contains the fenestra rotunda. In the *lion*, this fenestra corresponds precisely to the line of separation, and is situated at the hole by which the two parts communicate. The posterior part may be regarded as analogous to the large cells of birds, and it appears to be given only to animals that are remarkable for a quick sense of hearing.

In a number of *Sarcophaga*, and even in those I have named, there is another osseous ridge, but not so broad as the former, and transverse: it appears to serve merely as a support to the frame of the membrana tympani. The *horse* has a number of similar pieces.

In the *sapajous* and the *ant-eaters*, the cavity has also an additional cell formed by an osseous separation; but this cell is situated before the cavity of the tympanum, properly so called, or that part to which the membrana tympani belongs. The *stoth* has a cell at the base of the zygomatic arch.

The

The barrel or cavity of the tympanum in the *elephant*, has no septum; but its sides are furnished with a great number of prominent laminæ, which cross each other in every direction, and produce a multitude of irregular cells and sinuses. We find the vestiges of similar cells in the irregularities and depressions of the barrel in several Rodentia, particularly the *cabiai*, the *guinea pig*, the *marmotte*, and the *porcupine*.

In the *hippopotamus*, the barrel, properly so called, is extremely small; but it communicates by a hole with another cavity, divided internally into a great number of irregular cells, analogous to those of the *lion*, *civet*, &c.

In the *seal*, and the *morse*, the cavity of the tympanum is very large, rounded on every side, and undivided.

3. *Form and Proportions of the Fenestra Ovalis, and Fenestra Rotunda.*

We have already shewn, that the fenestra rotunda, which communicates with one of the scalæ of the cochlea, is only closed by a membrane. As it is always directed backward, we may suppose that it is chiefly destined to receive the sounds produced by the resonance of the posterior chamber of the barrel, which we have just described, and which is so distinct in nocturnal animals, the *cat*, the *lion*, &c. Scarpa

considers this membrane of the fenestra rotunda as a second membrana tympani.

In Man, the shape of these two fenestræ is conformable to the names which are given to them, though they are not perfectly regular. The oval fenestra is a little larger than the round.

In the other animals the variations are so considerable, both with respect to figure and dimensions, that the terms, oval and round, are no longer applicable : we shall substitute in their stead, the names *fenestra vestibularis*, and *fenestra cochlearis*.

Monkeys have them similar to those of man.

In *bats*, the fenestra cochlearis is the largest.

Both fenestræ are oval in the *mole* : a bar extends from one edge of the fenestra vestibularis to the other, and passes between the legs of the stapes. This occasioned the mistake of Derham, who believed that the stapes of the mole had no plate, but that one of its legs rested on the fenestra ovalis, and the other on the fenestra rotunda. The same structure is found in several other mammiferous animals. In the *marmotte*, the osseous bar, which passes between the legs of the stapes, is so thick, that when the latter bone is removed, there appears to be two fenestræ vestibulares : this bar is always hollow, and affords a passage for some vessels.

In the *Sarcophaga*, the fenestra cochlearis is commonly the largest ; it is nearly double the
size

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size of the other in *cats* and *civets*. The *ermine* has them almost equal. In the *opossum*, the fenestra vestibularis is round; the cochlearis is irregular and smaller.

In the *beaver* and the *marmotte*, the latter is triangular. In the *bare* it has the form of a small, and almost perpendicular fissure. The vestibularis is round, and much larger.

The *guinea pig* has them nearly equal, both directed upward, and separated only by a thin bar.

They are both oval, and nearly equal in the *Edentata*.

In the *Ruminantia* the cochlearis is the largest. The *calf* has it nearly double the size of the other. It is also twice as large, and situated very near the other in the *hog*. It is three times larger than the vestibular hole in the *hippopotamus*. In the *elephant*, on the contrary, it is very small, irregular, and concealed behind an elevation of the promontory.

The cochlear fenestra is largest in the *Solipeda* and the *Cetacea*.

4. *Eustachian Tube*.

The osseous part of this tube presents few differences that are remarkable in quadrupeds. That part is shorter in the *Sarcophaga* than in man. In *cats* and *civets* it is rather a narrow fissure, than a canal: it might be represented as a vacant space in the future, which unites

the bone of the barrel to what should be strictly called the *pars petrosa*.

The *otter*, the *badger*, and the *weazle*, &c. have a simple hole, separated from the rest of the cavity of the tympanum by a projecting longitudinal ridge. In the *hare*, the origin of the tube within the barrel is a triangular foramen. In the *cabiai* it commences by a half-formed canal, which becomes complete, in piercing the point of the *os petrosum*.

In the *elephant* it is a long and wide canal, which begins under the *membrana tympani*, and terminates at the point of the *os petrosum*; its parietes are smooth, and have no cells.

We have not yet sufficiently examined the cartilaginous part of the tube in quadrupeds to enable us to describe it.

In the *horse*, the lower end of the cartilaginous tube opens into a large membranous sac, situated at one side of the back of the mouth; this sac, on some occasions, is filled with pus, and then produces a dangerous pressure on the pharynx.

D. *Particular Description of the Barrel, or Cavity of the Tympanum, in Cetacea.*

The cavity of the tympanum in the *Cetacea* deserves to be described separately; it is formed by an ossious lamina, which has the appearance of being rolled upon itself, and which, with respect

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respect to its figure, may be compared to the shell, called *bullæ*, except that the thick side, instead of containing a spiral cavity, is entirely solid: this thick part is internal; it is more than two inches thick in the *cachalot*; its edge is blunt and rounded; the opposite side is thinner, and its edge is irregular: the membrane of the tympanum is situated between two of its processes: this barrel adheres to the os petrosum by its posterior extremity, and by a process of the anterior part of its thin edge. In the *dolphins*, the anterior process of the barrel also ascends to the os petrosum; but in the *cachalots* it does not reach that part. The anterior extremity of the cavity is entirely open, and there the membranous tube commences; this tube ascends along the pterygoid process, and perforating the os maxillare, terminates at the superior part of the nose. This position of the orifice, as well as the size of the tube, must render it more useful than the meatus externus to the Cetacea, in distinguishing sounds. In treating of the sense of smelling, we shall shew that, by a structure not less singular, the Eustachian tube also conveys the odoriferous emanations to the place where that sense resides.

The aperture by which this tube communicates with the nose, is furnished with a valve, which does not permit the water to enter when the animal ejects it by the blow holes.

ARTICLE V.

Of the Membrane of the Tympanum, and its Osseous Frame.

THE membrane, which closes the external aperture of the barrel, and which immediately receives the vibrations of the air, and transmits the impressions to the internal ear, is called *membrana tympani*, or sometimes simply *tympanum*.

1. *Substance of the Membrana Tympani.*

Animals which want the barrel of the tympanum, as fishes, salamanders, &c. have no *membrana tympani*. That membrane is also wanting in several reptiles that have a barrel, as the *camelion*: the skin passes over the external aperture of their ear, without undergoing any change, either in its thickness or its structure, and the existence of the organ of hearing can only be ascertained by dissection. On removing the skin, and some portions of the muscles, we find, in some species, and particularly in the *slow worm* (*anguis fragilis*) a kind of membranous expansion.

In the *tortoise*, the large external aperture of the barrel is closed by a very thick cartilaginous plate, which is itself covered by a scaly skin, perfectly similar to that of the rest of the head.

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In *frogs* and *toads*, the membrana tympani is on a level with the head, and the skin that covers it becoming finer, it is rendered perceptible by an oval spot, which is smoother than the rest of the head, and usually of a particular colour.

In *common lizards*, the membrana tympani is also level with the head, but very thin, smooth, and transparent, for at that part the skin becomes as smooth and fine as on the cornea of the eye.

In the *crocodile*, it is of the same nature, but more sunk into the head, and covered by two fleshy lips, which supply the place of the external ear.

All warm-blooded animals, *birds*, *Cetacea*, and *quadrupeds*, have, like *man*, the membrana tympani thin, transparent, dry, elastic, more or less sunk into the head, and preceded by a canal, to which, in some of these animals, is superadded the concha, or external ear.

Notwithstanding its fine texture, the membrana tympani is at least divided into three lamina: one, which is proper to it; one internal, which is the continuation of the internal membrane of the barrel, and which is itself derived from that of the mouth; and one external, which is a production of the skin.

2. Surface and Direction of the Membrana Tympani.

The membrane of *man*, and all other mammiferous

miferous animals, has a conical surface, the point of which is directed inward, and the concavity outward; this cone is very wide, and its apex does not correspond to the middle of its base. The *mole*, however, forms an exception to this rule, as its membrana tympani is plane.

In all birds, the disposition is the contrary of that of the mammalia: the apex is on the outer part.

In *lizards*, though the point projects less than in birds, it is also directed outward. It is nearly plane in *frogs* and *tortoises*.

The membrana tympani is on a level with the adjacent parts of the head, and consequently is nearly vertical in all animals in which its situation is superficial; but in those which have it sunk, its inclination, whether considered with relation to the head itself, or to the external meatus, varies considerably. We shall consider it with respect to the head, which must be supposed upright, and the plane of the palate horizontal.

The membrane of the tympanum inclines obliquely upward, and to one side in the *crocodile*: obliquely downward, backward, and laterally in most birds; and even more downward, in proportion as the bird hears weak sounds more distinctly. In the *owl* it is, therefore, very oblique. It is more vertical in the *goose* and the *parrot*.

In quadrupeds, the membrana tympani is also

also more oblique, with respect to the external canal, and inclined more downward, in proportion as the animal hears better. The *mole*, which has the sense of hearing very delicate, notwithstanding the want of the concha, has the membrane almost parallel to the base of the cranium, and answering as a floor to the barrel of the tympanum: this disposition doubtless takes place, in order that the membrane may be rendered more extensive. Another rule may, therefore, be deduced from observation, namely, that the larger the membrana tympani, all other circumstances being equal, the more acute is the sense of hearing.

In *otters*, *weazels*, and *badgers*, the membrane of the tympanum is almost as oblique as in the *mole*. It is also very oblique in the *pangolin*.

It is nearly vertical, and directed forward, in *man*, *apes*, *dogs*, *cats*, *civets*, and *coatis*.

It is almost vertical, and turned directly towards the side, in *hares*, *rabbits*, *marmottes*, and the greater number of Ruminantia.

3. *Frame of the Membrane of the Tympanum.*

The membrana tympani is attached to an osseous circle, which is called its *frame*. This frame forms the extremity of the meatus auditorius externus, next the barrel, and is that portion of it which first ossifies; it is nearly round, and makes only a slight projection inward, before which there is a furrow in man. In a great number

number of mammalia, it forms a projection within the barrel, which represents a narrow plate, circularly or elliptically twisted, one of the edges of which is attached to the external part of the barrel, and the other is unconnected. This free edge is more or less sharp and wide, according to the species; it is frequently sustained by some prominent spines, which proceed from different parts of the barrel, and join it perpendicularly. We have already noticed them in the last article.

This projecting frame is not perfectly complete. A segment, which, according to the species, is a greater or less portion of its circumference, is almost constantly wanting towards the upper part. The *guinea-pig*, the *paca*, the *seal*, and the *ant-eater*, are the only animals in which I have observed it entire. In the latter, however, it projects so little, that it is difficult to distinguish where it terminates.

It wants almost the whole of its upper quarter, in the *cat*, the *dog*, the *rabbit*, and the *rat*. The part wanting is rather proportionally smaller in the Ruminantia and the Solipeda. The *elephant* wants all the upper half.

The figure of the frame is commonly an oval, with the great axis descending obliquely forward, and the anterior arch less convex than the posterior. This oval is more oblong in the Sarcophaga than in herbivorous quadrupeds. It approaches a circular form, and has its sides
almost

almost equal in the *guinea-pig* and the *paca*: next to them the *rabbit* has it most regular.

Man and the *ant-eater* have it almost circular. It is perfectly round in the *mole*.

In the Cetacea, the membrane of the tympanum, properly so called, has no frame; but the barrel has three processes, which produce irregular notches in the aperture, and give it the figure of three unequal lobes.

In birds the frame of the membrana tympani is not so well defined as in quadrupeds, and does not project within the barrel. In some species, as the *white owl*, it is complete: others, and frequently very nearly allied species, as the *great-horned owl*, have it interrupted at its anterior part, and the membrane is attached to the square bone for the articulation of the lower mandible, a process of which, as we have already observed, always forms a part of the anterior parietes of the barrel, or cavity of the tympanum.

The figure of the frame of birds is also an oblique oval, the great axis of which descends obliquely forward; but it usually approaches more to the round form than in quadrupeds.

The direction of the great axis is less forward in several passeres; but all these differences are of little importance.

In reptiles, the frame is not marked by any prominent edge; it is interrupted posteriorly. Its great axis is vertical in the *tortoise* and the

common lizards, and its anterior arch is more convex. In the *crocodile* it is a regular oval, the great axis of which is directed obliquely backward.

ARTICLE VI.

Of the Ossicula which establish a Communication between the Membrana Tympani and the Fenestra Ovalis, and of their Muscles.

I. Of the BONES.

ALL the animals which have a real fenestra vestibularis, have it closed by an osseous plate of the same shape. This plate communicates by a pedicle or stalk with the membrana tympani, or, when that membrane does not exist, with the skin, or parts near it. The stalk is sometimes simple, and forms, with the plate, only one and the same ossiculum; sometimes the communication is maintained by two or four little bones of very different figures. This chain of ossicula is most complicated in the Mammalia, and with them we shall commence our description.

A. In Mammiferous Animals.

All the Mammalia have four ossicula, which are named *Malleus*, *Incus*, *Os Lenticulare*, and *Stapes*.

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The *malleus* is always formed of an elongated handle, which is thin and pointed, and which adheres to the *membrana tympani*, in the direction of a line extending from the superior edge of that membrane to the apex of its cone; and of a head which makes an angle with the handle, and extends backwards and a little upwards within the cavity of the tympanum.

The *incus* joins the head of the *malleus* by an articular surface. Its opposite part is divided into two points; one proceeds directly backward; the other descends in a direction nearly parallel to the handle of the *malleus*, but a little more backward and inward. The extremity of this second process articulates with the *ossiculum lenticulare*, which is the smallest bone in the body of mammiferous animals, and by it with the *stapes*. The latter takes its name from its figure, which is that of a stirrup. It forms almost a right angle with the branch of the *incus* which supports it, and proceeding directly inward, applies its oval plate or base to the *fenestra ovalis*. Each of these bones varies in its size, figure, and position in the different species. We shall examine some of these varieties.

1. *The Malleus.*

In *man*, the handle of the *malleus*, or hammer, is slightly compressed, and bent a little, in such a manner that its point is directed obliquely forward; the head is a little shorter than the handle,

handle, and forms with it an angle of 120 degrees; it is terminated by an oval mass, rounded at the end, the posterior side of which presents to the incus an articular surface, composed of four small planes. At the angle, formed by the head and the handle, there is a small spine directed upward, which is called the *short process of the malleus*. The neck, or portion of the head, which is a little contracted, has anteriorly a slender process, which is prolonged like a stile, and which is named *processus gracilis*: behind and above the neck there is also a small lamina projecting obliquely.

The malleus of the *orang outang* does not differ from that of man, except in having the head a little more pointed.

In the *sapajou* the head is one half shorter than the handle. The articular surface occupies the whole of the posterior part. The *processus gracilis* is continued in a plate, which extends along the whole of the anterior edge. It is very conspicuous in the *guenons*; but in them the head is also in a right line with the handle, and forms a projection forward. It is not distinguished from the handle in the *simia beelzebub*, except by its sudden enlargement.

In *dogs* and *cats*, the handle has the figure of a long pyramid with three sides, the narrowest of which adheres to the *membrana tympani*. The angle, which the head forms with it, is as large as in man; the neck is slender, and turns forward;

forward ; but the *processus gracilis*, or anterior apophysis, which is very long, is extended into a thin plate, and occupies the whole of the angle included between the head and the handle. The short process is very prominent : there is another apophysis at the internal surface of the neck, which supplies the place of the small spine in man.

The other *Sarcophaga* present no differences, except in the length of the processes. The anterior, for example, is longest and narrowest in the *badger*, and shortest and broadest in the *otter*.

It is very broad in the *mole*, and gives to the malleus a figure nearly rhomboidal.

In the *Rodentia*, the handle is compressed like the blade of a knife, and adheres to the membrane of the tympanum by one of its edges. The neck makes an obtuse angle with the handle, which bears, as usual, the short process. The head, after receiving the incus on its posterior surface, has its thick portion situated in the opposite direction, that is to say, forward. This massy portion is oval in the *cavia* and the *guinea pig*, and pointed in the *rabbit* and the *rat*. The handle of the *sloths* resembles that of the *Rodentia*; the head is like that of the human malleus. In the *ant-eater* it differs from the form it has in the *sloths*, in the neck only, which is thinner; and in the *pangolin*, in having the same part very short.

In all these animals, reckoning from the *Rodentia*, the small internal apophysis, or poste-

rior process of the neck, is almost obliterated. It is, however, found very distinct in the *hog* and the Ruminantia, which have the malleus very similar to that of the Sarcophaga.

The *seal* has the handle compressed; and the neck short, with scarce any anterior process; the head is slightly flattened, and circular from before backward.

There is no handle in the *dolphin*; but the membrana tympani has the form of an elongated tunnel, and its point is fixed at the base of the neck, which seems obliquely truncated. The anterior process is long and arched. The articular surfaces for the incus are not directed entirely backward, but partly upward, on account of the position of the labyrinth above the barrel. The malleus of the *whale* is, in every respect, similar to that of the *dolphin*, but double its size.

2. The Incus,

Or anvil, exhibits fewer differences than the malleus. In all the mammalia these two bones are articulated by a very close ginglymus, composed at least of two surfaces, and most commonly of four, in such a manner that each bone has a convexity crossed by a concavity. The principal variation in the incus of different species, occurs in the relative length and thickness of the two processes.

In *man*, the superior process, which is attached to the bone of the barrel by a ligament, is shorter and thicker than the inferior, which is articulated

lated to the stapes, through the medium of the os lenticulare; the latter is arched in such a manner that its convexity is directed outward; they form nearly a right angle at their junction. The same disposition takes place in the *orang outang*.

In the *guenons*, the superior process becomes more slender. It is almost as long as the other in the *sapajous*. In *monkies*, in general, the articular depression becomes deeper.

The two processes are slender, and nearly equal, in the *cat*. The *dog* has them like those of man. *Weasels*, *otters*, and *seals*, have the superior very short. The incus of the *mole* is angular; its inferior, or stapedian process, is very short and small; the other is very large, oblong, and hollowed posteriorly like a spoon. Perhaps it serves to lodge a muscle.

Hares and *rats* have the stapedian process very long, and the other scarce visible. They are more equal in the *cabiais*.

They are nearly equal, and make an obtuse angle, in the *sloths*.

The superior is most slender in the *sheep*.

They are both directed upward in the *dolphin*.

3. *The Ossiculum Lenticulare,*

Or *orbiculare*, notwithstanding its smallness, varies as to form in different species, but the variations it undergoes are too minute to be felt on here.

4. *The Stapes.*

This ossiculum differs, in several species, in the separation and curvature of its branches, in the extent of the vacancy between them, and in the figure of its basis or plate.

In *man*, for example, the branches are arched, and the basis or plate is semi-oval.

In the *sapajou*, the branches are nearly straight, and the basis forms a narrow ellipsis.

No animal has the branches more arched, and proportionally more separate than the *mole*, in which the basis has the figure of an elongated and narrow ellipsis.

In all animals, the posterior branch is thicker than the anterior. Instead of the two branches, the Cetacea have a solid body, compressed conically, and perforated by only a very small foramen. In the *lamartin*, this part of the stapes represents a twisted cylinder; on one side there is an oblique groove, and the foramen has the appearance of the puncture of a pin. The surface, attached to the fenestra ovalis, is exceedingly convex.

B. *In Birds.*

Birds have only one ossiculum, composed of two branches, which form an elbow: the first is attached to the membrana tympani, from its inferior and posterior edge, to the apex of the projecting cone, which that membrane forms externally; its direction is, therefore, almost
the

the contrary of that of the malleus, to which this branch corresponds. At its union with the second part of the bone, there are two cartilaginous processes, the posterior of which joins a third branch, which runs back to the first part of the bone. In this manner, a triangle, nearly right angled, is formed, the three sides of which are attached to the membrane of the tympanum. The other part of the ossiculum makes an acute angle with this first branch, and then passes directly into the barrel, in the form of a slender osseous stalk; it there expands a little, and sometimes is divided into two or more small osseous filaments, after which it terminates in an oval or triangular plate, which, like the basis of the tapes in mammalia, closes the vestibular fenestra. There is no difference among birds with respect to this ossiculum, except in its size, and the shape of the plate. The small branches, which adhere to the membrana tympani, vary, it is true, in their relative inclination and magnitude, but in a manner too unimportant to merit notice.

C. *In Reptiles.*

The *frog* and the *toad* have two ossicula in the ear; one supplies the place of the malleus, and the incus: it is attached to the membrana tympani by a slender branch which forms an acute angle with the part that passes into the barrel; that part has the shape of a club; its internal extremity is the thickest, and articulates by a double surface to the second ossiculum, which

corresponds to the stapes: the latter has a semi-elliptic form, and is applied to the fenestra ovalis by its plane surface; both these bodies, which are osseous in other animals, are cartilaginous in the *frog* and *toad*.

Lizards and *tortoises* resemble birds, in having a single ossiculum with a thin hard stalk, and an oval or triangular plate. It is attached to the membrane of the tympanum in the *lizards*, and particularly in the *crocodile*, by a cartilaginous branch; but in the *tortoise*, its outward extremity is directly implanted in the cartilaginous mass, which corresponds to the membrana tympani itself.

In the *crocodile*, the plate is an elongated ellipsis, the great axis of which is situated longitudinally.

In the *tortoise*, the bone is enlarged in the form of a trumpet, and is applied to the fenestra by a regularly oval and concave surface.

Serpents have an ossiculum, but no membrana tympani; its external extremity touches the bone that supports the lower jaw; it is surrounded by the flesh, and is applied to the fenestra by a concave plate, the edges of which are irregular.

In the *camelion*, the plate also resembles the wide end of a trumpet; its stalk becomes cartilaginous, and is lost in the flesh.

The fenestra vestibularis of *salamanders* is closed only by a small cartilaginous operculum, which has no stalk, and is concealed by the flesh.

II. *Of the MUSCLES.*

In man and other mammiferous animals the ossicula have four muscles; three to the malleus, and one to the stapes.

The incus has no muscle: its head is attached to the posterior surface of the head of the malleus, and the extremity of its superior process is fixed to the temporal bone in the upper and posterior part of the bottom of the barrel of the tympanum. It shares in all the motions of the malleus, which makes it act like a balance upon its fixed point.

The muscles of the malleus are,

1. *The Tensor Tympani, or Internus Mallei.*

This muscle arises from the cartilaginous part of the Eustachian tube, and runs in a half formed canal situated in the os petrosum, upon the osseous part of that tube. Soon after it enters the barrel, it reaches an eminence situated before the fenestra ovalis, which has been likened to the spout of an ewer. Its tendon turns upon this eminence. It is then directed outward, and inserted into the internal surface of the manubrium mallei under the processus gracilis. It pulls the malleus completely inward, and stretches the membrane of the tympanum: by the motion which the malleus communicates to the incus, the superior leg of which remains fixed, its inferior leg must describe an arch from without

inward, and press the stapes into the fenestra ovalis.

2. *The Externus Mallei,*

Proceeds parallel to the preceding muscle, but more outwardly. It is inserted into the slender process of the malleus, which is itself lodged in a small canal formed above the superior edge of the frame of the membrana tympani. This muscle is so delicate that its real nature can scarcely be ascertained. When it acts, it must draw the malleus forward, and thereby stretch the posterior half of the membrana tympani, and communicate a balance-like motion to the incus. In this movement the head of the incus is lowered, the extremity of its inferior process is directed backward, and a tremulous shock is given to the stapes in the fenestra ovalis.

3. *The Laxator Tympani.*

This muscle arises from the arch of the meatus externus, near the membrana tympani, passes through the notch of the frame of that membrane, and is inserted into the small oblique process, on the neck of the malleus: it pulls that bone outward, and thereby relaxes the tympanum. In consequence of the motion communicated to the incus, it must, at the same time, draw the stapes a little from the fenestra ovalis.

The single muscle of the stapes, or—

The Stapedius,

Lies within the cavity of a projection situated behind

behind the fenestra ovalis, near the posterior edge of the barrel, which is called the *pyramidal eminence*. Its tendon comes forth from the cavity, and proceeds directly to the posterior part of the stapes, which it pulls backward, raising at the same time its anterior part a little.

We have not examined these muscles in a great number of mammalia; but we have seen most of them, and particularly the stapedius, and tensor tympani, in several species, in which they have presented few varieties.

The malleus of the *dolphin* appears to have no muscle, but there is evidently one to the stapes, which is attached very far up, and not in the middle of one of the branches, as in man.

The pressure of the stapes on the fenestra ovalis must have a double effect: it first agitates the whole interior of the labyrinth:—secondly, it compresses the gelatinous substance which the labyrinth contains, and forces it through the cochlea, on the membrane of the fenestra rotunda, which will thereby be rendered more tense.

The second effect must, in particular, depend upon a fixed pressure produced by the action of the muscles: these are doubtless contracted, when we wish to listen with great attention.

As to the simple concussion, or shock, it may be caused merely by the agitation communicated to the membrana tympani by the vibrations

tions of the air: this is, probably, one of the immediate causes of hearing. Animals that have no muscles to their ossicula, are only susceptible of this kind of impression: it would be interesting to discover whether they are capable of paying more or less attention to sounds.

Birds have a small muscle behind the ear, on the occiput; it penetrates into the barrel by a hole, and is inserted into the hypotheneuse of the small right-angled triangle, formed on the membrana tympani by the three branches of the ossiculum: this muscle stretches the membrane, by drawing its conical apex more outward. Two filaments, which appear to be tendinous, oppose the action of this muscle, and prevent it from becoming too great: one filament, which is very long, arises from the anterior process of the cartilage attached to the tympanum, and is fixed in the cell situated above the Eustachian tube; the other ascends, and is inserted into the column which separates the entrance of that cell from the one above the labyrinth.

We are not sufficiently acquainted with the muscles of the internal ear of reptiles; and the descriptions of Comparetti do not possess that clearness which might enable us to supply the want of our own observations.

It appears that *serpents*, *camelions*, and *salamanders*, are entirely destitute of those muscles, and that they are very indistinct in *tortoises*.

ARTICLE VII.

Of the Meatus Auditorius Externus, of the Concha, and of the Muscles of the External Ear.

THE reptiles have no external meatus auditorius. In the *crocodile* only we find some appearance of that part, because the skin forms a kind of lip, or operculum, above the membrana tympani; and the latter is entirely concealed, except when this covering is removed. This is, doubtless, the part which Herodotus regarded as the external ear of the *crocodile*, and to which, he says, the Egyptians attached rings.

The external meatus of birds is very short; the orifice is commonly only a simple hole, level with the head, and surrounded with feathers of a particular structure; they are fine and elastic, and their radii, or beards, are simple, small, elastic, separate from each other, and allow the air to pass between them. These feathers are placed with much regularity about the aperture which they cover. In some birds they are elongated, and assume various forms, as in the *bustard*, the *tufted-necked humming bird* (*Trochilus ornatus*), a species of *bird of Paradise*, (*Paradisea aurea*,) &c.

In the *owls*, the external orifice of the ear is situated in the bottom of a large cavity, hollowed

lowed out on each side of the head, and lined by a naked skin, the folds of which form septa, which divide it like the human concha; this cavity would, indeed, resemble the external ear of man, were it projecting, and capable of motion.

The fine feathers which cover the cavity, form the circles that give to the physiognomy of those birds its singular character. The *white owl* has a membranous operculum, of a square form, at the anterior edge of the cavity.

We shall now examine the external ear in man, and other mammiferous animals.

1. *The external Osseous Meatus.*

The external meatus is osseous at its inner part, or that next the tympanum. The tubular portion of the cartilage of the external ear is attached by membranes and ligaments to this bony part; it sometimes forms only a single piece with the concha, and sometimes is separate from it.

The Cetacea are the only mammalia that have no osseous meatus: their external meatus is a very slender cartilaginous canal, which commences at the surface of the skin, where, in the *dolphin*, it would scarcely admit a pin; it takes a serpentine direction, as it passes through the lard, under the skin, to reach the membrana tympani.

In all the other families there is an osseous canal,

canal, of greater or less length; at least in adults, for it is longer in ossifying than most of the other bony parts of the ear. The frame of the membrana tympani only is ossified in infancy, and preserves its size, while the rest of the temporal bone continues to increase.

In man, the external osseous meatus is short, straight, and directed almost horizontally inward, and a little forward; its section is an oval, the great axis of which descends from before backward; its diameter remains nearly the same throughout its whole length.

It is, proportionally, a little longer and narrower in the *guenons*, and still more so in the *Barbary ape*; it descends a little in these species, but is not directed so far forward as in man; it is very short and circular in the *sapajous* and the *bats*.

The *Sarcophaga*, in general, have it like man, nearly horizontal. In *dogs*, *cats*, and the *badger*, it proceeds directly inward, and does not incline either forward or backward.

It is directed a little forward in the *coati*.

In the *otter*, the *pole-cat*, and, in general, in the genus *mustela*, it is directed backward.

The external canal of the *mole* is very singular; it is flat in the vertical direction, but enlarges in the horizontal; and the great circular membrana tympani serves for its roof, in the same manner as it forms the floor of the barrel.

This canal is directed very much downward
in

in the Rodentia, particularly in the *hares*. It also proceeds forward in this genus, and in the *marmotte*.

Its direction is inward and downward in the *beaver*.

The *porcupine* has it turned backward.

In the *cabiais*, and the *agoutis*, it is short, and runs straight inward; under its inferior edge there is a hole, which penetrates into the cavity of the tympanum, and, in some species, unites with the meatus by a fissure.

The *sloths*, *pangolins*, and *ant-eaters*, have the external meatus very short, wide, and circular.

In the *elephant* it is large and long, and is directed a very little downward and backward.

It descends at an angle of 45 degrees in the *rhinoceros* and the *hippopotamus*, but is neither directed forward nor backward. In the *babiroussa* it has the same inclination, but is directed a little forward. In the *common hog* it descends still more, and also inclines forward. All these animals have it very long and very narrow.

It is shorter in the *horse*, in which it descends less abruptly, and is inclined a little backward.

Lastly, in the Ruminantia it proceeds directly inward, with a slight inclination upward.

II. *The external Cartilaginous Meatus, and the Concha.*

The Cetacea excepted, there are very few
mammi-

mammiferous animals which have not, at the orifice of the external meatus, that kind of cartilaginous expansion, like the end of a trumpet, which is called the *concha*.

Those which want it are, in the *Sarcophaga*, the *mole*, and some *shrews*. In the *Rodentia*, the *zemm*i, and some *mole rats*. In the *Edentata*, the *pangolins*. And in the amphibious mammalia, the *morse*, and several species of *seals*.

We observe great varieties in the *concha*, or external ear of different animals: these variations relate to its size, position, figure, and internal eminences, to the composition of its tube, and, finally, to its muscles.

a. *Size.*

The animals which are remarkable for the size of the ear, are almost all timid or nocturnal, and therefore require a delicate sense of hearing, as the feeble *Ruminantia*, the *gazelles* and *deer*, the *ass*, *hares*, and some small *Rodentia*, but particularly the *bats*.

In the last genus, there are several species which have the ear as large as the whole of the head; and one species, the *eared bat* (*vespertilio auritus*,) has it as large as the body.

The *African elephant* is distinguished by a large, flat, open ear, situated close to the body, and therefore not well calculated to answer the purpose

purpose of an acoustic trumpet. The ear of the *Indian elephant* is similar, but much smaller.

b. *Direction.*

Naturalists have remarked, that the aperture of the concha is most frequently directed forward in the animals that hunt for their food, and backward in those that are their prey; but this position depends upon the necessity of the moment, and not upon any peculiar structure of the organ. All animals which have ears of a certain length, may vary their direction at pleasure, except, perhaps, the *vespertilio spasma*, which has the two great ears united by their internal edges, and consequently very little moveable.

Ears with the superior part of the concha pendent, are a mark of slavery. *Dogs, sheep, goats, and hogs*, have them always thus in some of their domestic varieties. The *elephant* has also a pendulous ear, but unlike the preceding animals, it is the posterior and inferior part of the ear that hangs down.

c. *Figure.*

The concha of the human ear has the shape of half an oval, more contracted inferiorly, and terminated by a lobe which is filled with fat. The anterior edge adheres to the rest of the skin, and is almost rectilinear, with the exception of
the

the eminences, of which we shall speak presently : the superior and posterior edges are free, and directed outward.

In the *orangs* and *ſapajous*, the lobe diminishes, and the free part becomes more considerable, but remains round. In the *guenons* and *macaques*, it is pointed a little ſuperiorly. In the *ſtriated monkey* (*Simia jacchus*), it is even grooved poſteriorly by a ſinuofity. The form of the ear varies in the other genera, without any direct relation to the orders to which they belong. In general it becomes more elliptical as it increaſes in ſize ; it belongs to ordinary Natural Hiſtory to deſcribe thoſe ſmall variations of ſhape, which are entirely external. It is ſufficient, therefore, to refer our readers to plates which repreſent quadrupeds.

d. *Eminences.*

The eminences of the human ear are, 1. The fold of its ſuperior and poſterior edge, called *helix* ; it turns inward, below its anterior part, and is terminated above and behind the external meatus. 2. The ſharp elevation, which is almoſt parallel to the helix poſteriorly, and which afterwards croſſes the ear obliquely, named *antihelix*. 3. The eminence, ſituated before the meatus, and denominated *tragus*. 4. That which is ſituated behind the meatus, which terminates the *antihelix* inferiorly, and which is called *tritragus*.

The fold which forms the *belix* diminishes in *apes*, disappears in the *sapajous*, the *striated monkey*, and in all other animals; they have all a sharp edge to the ear. The *antibelix* becomes flat, and is replaced by a transverse eminence situated very low down.

The *tragus*, which still exists in the *dog*, is reduced in the *hares*, *horses*, &c. to a slight projection of the superior edge of the concha on the inferior.

In the *bats*, the *tragus* is particularly developed, and assumes very remarkable forms.

In the *eared bat*, it is so large that a double concha has been ascribed to that animal: it is forked in the *vesp. spasma*; notched in the *v. leporinus*, and the *v. crenatus*; oval, round, pointed, &c. in the other species. It may serve to prevent the too violent irruption of air into the ear while the animal flies. The *antitragus* of bats is generally round; it is sometimes prolonged forward, beyond the *tragus*, to the angle of the mouth. It is found of that form in the *v. molossus*.

In some *shrews* the *antitragus* serves as an operculum to the ear. It closes it exactly in the *aquatic shrew* of Daubenton.

e. Composition.

The external ear of man consists of a single piece: the concha becomes tubular, and preserves that form until it reaches the osseous meatus,

meatus, to which it is intimately united: we observe only one fissure or irregular incision.

In animals which have the ears rather long, and very moveable, the tube of the ear is divided into two parts, one of which is connected with the concha; the other forms a particular tubular cartilage, attached to the osseous meatus by a ligament, and has, like the portion united to the concha, a longitudinal fissure. In consequence of this division, the tube may be shortened and elongated, as well as dilated and narrowed.

These animals have, besides, a third cartilage, situated above the tube of the ear; it is flat, and forms no part of the concavity, but merely serves as a point of attachment for some muscles.

This cartilage is triangular in the *horse*; lunated in the *sheep*; pointed posteriorly, and bilobed anteriorly, in the *rabbit*; and rhomboidal in the *dog*. We shall call it the *scutum*.

III. The MUSCLES.

A. In Man.

The number and size of the muscles of the external ear, depend upon its degree of mobility; their shapes and proportions on the position of that organ, which, in its turn, is influenced by that of the exterior orifice of the osseous meatus.

This orifice is always situated close behind the articulation of the lower jaw; it is, therefore,

farther back, and nearer the occiput, in proportion to the length of the jaws, compared with that of the cranium. It is also more elevated with respect to the whole head, in proportion as the ascending branches of the lower jaw are higher, and the cranium more flat. Thus descending from man, we find that its situation becomes progressively more upward and backward, and that the two ears approach more and more towards each other, until we come to the Solipeda, in which the approximation is greatest.

The muscles which act on the human ear are reducible to three which arise from different parts of the head, and five which proceed from one point of the concha to another.

The three first are—

1. *The Superior Auris.*

This is a thin radiated muscle; it covers a part of the temple, and is inserted into the superior portion of the convexity of the concha.

2. *The Anterior Auris,*

Which is small, and not very distinct from the preceding; it arises near the zygomatic arch, and terminates in the anterior part of the convex side of the concha.

3. *The Posterior Auris.*

This is a small muscle, divided into some
8 slips

flaps which arise from the occiput, and are inserted behind the concha.

The five muscles of the concha are—

1. *The Major Helicis.*

It arises above the tragus, and is lost on the anterior edge of the helix.

2. *The Minor Helicis,*

Which is extended over that part of the helix which runs across the concha.

3. *The Tragicus.*

The fibres of this muscle are extended transversely over the tragus.

4. *The Antitragicus.*

It arises from the antitragus, and is lost on the internal edge of the antihelix.

5. *The Transversus Auris.*

This muscle extends across that hollow fold, on the back of the ear, which corresponds to the projection made by the antihelix upon the concave surface.

These muscles have no apparent use in most men. Some of them have, however, been observed to produce a slight motion of the ear.

B. *In Quadrupeds.*

The muscles of the ears of quadrupeds are,

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in general, very numerous : they may be divided into four classes : 1. Those which arise from the head, and are inserted in the scutum : 2. Those which have also their origin in the head, and are inserted in the concha, or its tube : 3. Those which proceed from the scutum to the concha : 4. Those which extend from one part of the concha to another.

These muscles move the ear in every direction, or turn it on its axis in such a manner that the superior surface is sometimes placed forward, sometimes backward, and the inferior in the opposite directions. We shall describe these muscles in the *horse*, the *sheep*, the *rabbit*, and the *dog*.

a. *Muscles which proceed from the Head to the Scutum.*

1. *The Vertico-Scutalis,*

Arises in the *dog*, from the middle line, along the whole of the upper surface of the head ; and in the *horse*, from the superior edge of the temporal fossa : it is inserted into the superior edge of the scutum. In the *sheep* it is reduced to a band, which comes from above and behind the orbit ; and in the *hare*, to a still narrower slip, arising from the occipital crest merely : this is the *communis* of Lafosse, and the *fronto-auricularis* of Girard ; it raises both ears, and draws their convex surfaces towards each other.

2. *The Jugo-Scutalis.*

This muscle arises in the *horse* from the zygoma, ascends backward, and is inserted into the anterior edge of the scutum. In the *dog*, it comes from the skin of the cheeks, and expands considerably, as it proceeds upward, where it is inserted, not only into the scutum, but also in the anterior edge of the preceding muscle. It is wanting in the *bare* and the *sheep*. It draws the ear forward, and a little upward.

3. *The Cervico-Scutalis.*

It comes from the cervical ligament, and is inserted in the posterior edge of the scutum; it is peculiar to the *dog* and the *rabbit*, and approximates the ears posteriorly.

b. *Muscles which proceed from the Head to the Concha, or to its Tube.*4. *The Vertici-Auricularis,*

Arises from the crown of the head, passes under the vertico-scutalis, and expands on the concha towards its anterior edge; it is proper to the *horse* and the *sheep*, and approximates the conchæ very considerably while it elevates them.

5. *The Supercili-Auricularis,*

Supplies the place of the preceding muscle

in the *bare* and the *dog*; it comes from the superciliary arch, passes before the margin of the scutum, and is attached to the concha. In the *bare* it is inserted by a slender tendon. In the *dog* it is united throughout almost its whole length, to the anterior edge of the vertico-Scutalis, and is inserted by an expansion very near the anterior edge of the concha.

6. *The Cervici-Auricularis.*

It arises from the cervical ligament, passes behind the edge of the scutum, and expands on the concha, which it moves backward, and draws towards that of the other side.

7. *The Occipiti-Auricularis,*

Comes from the parts near the occipital crest, and passes below the scutum and the last muscle; it is attached to the concha, which it elevates, but does not move it backward. It is not found in the *bare*.

8. *The Cervici-Tubalis Profundus.*

It arises from the cervical ligament below the cervici-auricularis; it is inserted at the origin of the tube of the ear, which it draws backward. It is double in the *horse*, and wanting in the *bare*.

9. *The Occipiti-Auricularis Rotator,*

Arises from the posterior part of the occiput,
and

and is inserted in the form of a band into the concha, near its tube: this muscle is found in all long-eared animals; it turns the ear on its axis, by directing its concavity outward and backward when it is erect, and downward when it is horizontal.

10. *The Parotido-Auricularis,*

Which comes from the parotid gland, and the parts next the skin, is inserted under the concha, near the tragus; it lowers the ear, and is always found. The *bare* has it longer than others.

11. *The Jugo-Auricularis.*

In the *sheep* this muscle is very conspicuous; it arises from the anterior part of the zygomatic arch, and runs backward to its insertion in the edge of the concha, next the meatus auditorius. In the *dog* it is double; one portion comes from the skin of the cheek; the other from the posterior edge of the jugo-scutalis. In the *horse*, one portion arises from the middle of the zygoma, and another from the posterior edge of the jugo-scutalis; it draws the ear horizontally forward. It does not exist in the *bare*.

12. *The Jugo-Auricularis Profundus.*

This is a small slender muscle, found in all the before-mentioned animals; it is attached to the posterior part of the zygomatic arch, near the articula-

articulation of the lower jaw, and extends to the part of the concha next the tube, a little superiorly : it serves chiefly to shorten the tube of the ear.

The *horse* has two muscles belonging to this class, which are not found in the other species, viz.

13. *The Vertici-Auricularis Rotator.*

This muscle comes from the top of the head near the occipital eminence ; passes under the posterior angle of the scutum, and over the occipiti-auricularis ; proceeds obliquely forward, and is expanded, like a scarf, on the anterior part of the concha, near its tube : it turns the ear on its axis, directing the concavity forward and inward when it is erect, and upward when it is horizontal.

14. *The Vertici-Auricularis Profundus,*

Has a common origin with the preceding ; it separates from it under the scutum, and descends between the head and the concha ; it is inserted in that part of the latter, which is inward, when its concavity is directed outward, and which is nearest the tube ; its use appears to be to lengthen the tube of the ear.

c. *Muscles which unite the Scutum to the Concha, or to the Tube of the Ear.*

α. The *superficial*, which are attached to the scutum.

15. *The*

15. *The Scutalis Anterior,*

Extends from the inferior edge, and anterior angle of the scutum, to the front of the concha, which it turns on its axis, and directs upward and forward when horizontal. It is wanting in the *dogs* that have hanging ears.

16. *The Scutalis Posterior,*

Proceeds from the same edge, and sometimes from the same angle, and extends backward behind the concha, which it elevates. It is wanting in the *bare*.

β . The *deep-seated*, which are inserted under the scutum.

17. *The Scutalis Rotator.*

This muscle arises under the scutum, and proceeds in the form of a scarf, behind the part of the concha which is next the tube. It turns the concavity of that part towards the earth, and backward when it is horizontal. It is double in the *bare*.

d. *Muscles which extend from one Part of the Concha of the Ear to another.*

There are no muscles of this kind in the *sheep*, and only one in the *horse*, viz.

18. *The Tragicus.*

It is situated on the fissure of the concha, and produces

produces the crossing of the edges of that part ; it consequently contracts the aperture of the external meatus ; it also exists in the *dog* and the *bare*. In the latter it is accompanied by

19. *The Tubo-Helicus,*

Which comes from the cartilaginous tube of the concha, and which shortens the tube of the ear.

We find in the *dog*,

20. *The Plicator Auris.*

This muscle is analogous to those of the helix in man ; it extends along the anterior edge of the concha, near its base ; it folds, and depresses the superior part of the ear.

Lastly, the *dog* and the *horse* have, on the back of their concha,

21. Some scattered fleshy fibres which are analogous to the transversus auris of man.

ARTICLE VIII.

Of the Distribution of the Nerves within the Ear.

WE have described the *meatus auditorius internus*, in pages 46 and 56 of this volume. Its bottom is situated nearly opposite to the middle of

of the cochlea. It is divided into two fossæ by an osseous ridge. The superior contains a hole for the facial nerve, and a number of small foramina for a branch of the auditory nerve. The second also contains several foramina for the other branches of the auditory nerve.

We have described the origin of this nerve pages 151 & 177; and its course to the ear, pages 233 and 234. The inferior fossa through which the chief part of the nerve passes is oval. Its great diameter is transverse. Anteriorly there is a particular depression which corresponds to the basis of the conical axis of the cochlea. It is perforated by a vast number of small foramina, ranged in a spiral manner, and which extend into the holes of that cavity. In the posterior part of the fossa there are other clusters of similar small holes, but disposed in a circular order. One of these clusters leads into the vestibulum, and two others into the semi-circular canals. There is a fourth group, situated, as we have already observed, in the superior fossa. These small foramina lead also into the canals.

The nerves are greatly subdivided in perforating the osseous parietes, so that they arrive in the labyrinth divided to an incredible degree of minuteness. Those which enter into the cochlea, after having followed the parietes of its axis, penetrate, according to Scarpa, into the substance of its bony septum, and come out on the unconnected side of that septum.

The

The nerve, when enclosed in the internal auditory canal, appears twisted on itself; and its filaments, when beginning to be apparent, assume an oblique spiral direction.

They soon divide into four fasciculi, one of which corresponds to the beginning of the superior semi-circular and external canal; one to that of the posterior, and the third to the middle of the vestibulum. The fourth, which is the continuation of the trunk, is twisted spirally to pursue the series of small foramina which enter into the cochlea. Its filaments fill all the tubes of which these small holes are the orifices, and it is thus distributed in this part of the labyrinth to terminate in the membranous part of the septum. Numerous anastomoses take place among those filaments along the pyramidal axis.

As to the three other fasciculi, the first, which is the largest, having penetrated into the osseous vestibulum by one of the small sieves of which we have spoken, is divided into two small portions, which extend to the ampulæ of the two nearest semi-circular canals.

The second proceeds without dividing into the ampula of the posterior canal. The filaments of these two fasciculi terminate in these ampulæ, where they spread out like a fan, and form a kind of septum. The canals receive no nerve in any other part.

The third fasciculus is situated between the two preceding. It extends into the membranous

A. VIII. DISTRIBUTION OF THE NERVES. 543

branous vestibulum, and is distributed on its internal surface in a net-work as soft as it is complicated.

We shall in this place describe the course of the *facial nerve* through the ear. We pointed out the origin of this nerve, page 152. The hole into which it enters at the bottom of the internal meatus, is the orifice of a long canal bent in different directions, and called *aquæductus Falopii*. This canal perforates, in the first place, the pars petrosa, as it ascends outwardly. It soon receives another small canal, which extends from before backward, and which conveys a branch of the Vidian nerve of the fifth pair, to its union with the facial. (See page 211.) The aqueduct afterwards proceeds suddenly backward, and crosses the upper part of the barrel, where it is partly membranous. It then becomes osseous, is bent, and descends vertically parallel to the posterior part of the barrel, as far as the stylo-mastoid-foramen.

In page 228 and the following pages, we have described the distribution of the facial nerve after it comes out of the last foramen; but while it is passing through the aqueduct, it detaches, 1st, a nerve to the tensor tympani; 2d, one to the muscle of the stapes; and 3d, a long filament which passes through the cavity of the tympanum, as we have shewn in page 227, to unite with a branch of the inferior maxillary nerve of the fifth pair. This filament has been
named

named the *chorda tympani*, because it is situated behind that membrane in a manner similar to the cord which crosses the under head of a drum. It separates at an acute angle, and ascends in a small canal which opens into the cavity of the tympanum, under the pyramidal eminence. It leaves the barrel by the *fissura Glazeri*. We have already described it in page 227.

The external meatus receives nerves from the inferior maxillary branch of the fifth pair, and from its superficial temporal branch (see p. 217.) The back of the concha, and its muscles, derives their nerves from the occipital branch of the facial (see p. 228,) and from the second cervical pair (see p. 248,) which also sends filaments to the concave part of the concha; but this part receives, beside, another branch of the facial nerve (see p. 228.)

The nerves of the internal ear of mammiferous animals do not differ essentially from those of man. The nerves of the external ear are larger, and more numerous, in proportion to the size of the concha and its muscles; but they all have the same origin.

In birds, the depression which occupies the place of the internal meatus, is oval, and its greatest diameter almost horizontal; it contains five holes for the passage of the nerves, one of which receives the facial, and four the auditory; three of the latter penetrate into the osseous vestibulum, and one into the cochlea. The three
ramifi-

ramifications of the auditory nerve, which go to the semi-circular canals, are distributed to the ampullæ, as in man, and the mammalia. The ramification which goes to the cochlea extends to the uppermost of the two cartilages which form the septum of that organ; when it has reached one half of its length, it penetrates it, and is expanded, like a goose's foot, on the apex of the cone of the cochlea. Several filaments ascend in the contrary direction of the trunk, to proceed to the base of the same cone.

The facial nerve of birds receives a filament from the par vagum, similar to that which we have described in the *calf*, page 230; it crosses the ear in an osseous canal, and, having left the cavity of the tympanum, is distributed principally to the palate.

In reptiles and fishes, but particularly in the latter, we have the opportunity of observing, still better than in warm-blooded animals, the constancy with which the branches of the auditory nerve proceed to the ampullæ of the semi-circular canals: in the reptiles, it divides before it passes into the osseous labyrinth, which enters by several holes. In the chondropterygious fishes, it penetrates by a single hole, and is not divided until it is in the labyrinth. In the other fishes it has no septum to perforate, the ear being situated within the cavity of the anium; but it is detached by several branches

from the nerve of the fifth pair, of which it forms a part.

In the *rays* and the *sharks* there are always two branches; the smaller one detaches filaments to the sac, near the small amylaceous substances, and is afterwards divided in the two ampullæ of the anterior and horizontal canals. The other forms an expansion, like a goose's foot, in that part of the sac which contains the largest amylaceous substance. These numerous branches frequently anastomose.

The facial nerve enters the ear by a particular foramen; it joins a branch of the auditory, which extends into the ampulla of the posterior canal; it then separates, to come out by a second foramen, and is distributed to the teguments of the head and the adjacent muscles.

The auditory nerves of fishes are frequently three or four in number, and are detached separately from the nerve of the fifth pair; they extend to the ampullæ, and to the sac which contains the stones: they expand, in particular, on those stones; in numerous filaments; when they are large, the net-work formed by the filaments is exceedingly beautiful, as may be observed in the *cod*. The size of the nets decrease with that of the calcareous bodies.

LECTURE FOURTEENTH.

OF THE SENSE OF TOUCH, AND ITS ORGANS:

ARTICLE I.

Of the Sensations produced by Touch or Feeling.

THE sense of touch seems to afford us a more intimate communication with external bodies than those of sight and hearing, because there is no intermediate substance between them and us when these bodies act upon that sense: though, therefore, not entirely free from error; it is less capable of deceiving us than the other senses, the impressions of which it serves to verify and to perfect, particularly those of sight. By touch alone we obtain the idea of the three dimensions of bodies, and consequently of their figures as solids. The pressure, more or less forcible, more or less direct, made by the different parts of an external body, when applied to our skin, enables us to recognize whether that body be flat or round, or formed with various angles. By the equality or inequality of this pressure, and the degree of friction which

takes place when we move any part of our skin along the surface of another body, we ascertain whether that surface is smooth or rough. The degrees of resistance which bodies oppose to the pressure of ours, in whole or in part, afford us the means of determining whether they are moveable or immoveable, hard or soft, fluid or solid; and the pressure or percussion of these bodies on us, while in motion, or tending to move, makes us acquainted with the force with which they act, and the direction of that force.

All these actions of external bodies on our own are purely mechanical. The sensations they communicate may be the effects of a chemical change in our nervous system; but that change can only be produced in consequence of simple pressure being capable of forming or destroying some of the combinations which enter into this system. This supposition is not inconsistent with analogy: we know, for example, that the combination of fire with water, which produces vapour, may be destroyed by the same means.

But the sense of touch also procures us sensations of another kind, which appear to be produced by one of the surrounding elements penetrating more intimately our bodies; I mean the sensations of heat and cold. These sensations depend on the proportion which exists between the quantity of caloric we acquire or lose in a given moment, and that which we acquire

quire or lose in the preceding moment ; but they are not in direct relation with the absolute heat of bodies, nor even with the proportion between their heat and ours.

All things in other respects equal, bodies which have an higher degree of temperature than our own appear to us to be warm ; those which are of a lower temperature seem cold. When, however, we have touched a very cold body, if we come in contact with another which is less cold, the latter will appear to us warm, though it may still be of a temperature much inferior to that of our own body. Thus cellars and spring water appear warm in winter, because they preserve their ordinary temperature, while other bodies change theirs.

When we touch in succession two substances of different density, or, to speak more properly, of different capacities for caloric, that which has the greater capacity appears to us colder, though both may be of the same temperature, because it abstracts more caloric from us in a given time than the other. For this reason marble and metals appear always cold. Water is colder than the air, and the air, which seems cold before we enter into cold water, appears warm when we leave the water, &c.

Bodies which are good conductors of caloric, or which transmit it rapidly, for the same reason appear cold. Thus we find that silk or wool are warmer than linen of equal thickness.

This part of the sense of touch is liable to many more errors than that by which we obtain a knowledge of the figure and consistence of bodies, because our judgment possesses more influence in the latter case.

The general organ of touch resides in the skin which covers the whole body, or rather in the extremities of the nerves which terminate in that skin.

That organ possesses greater or less sensibility, in proportion as the nerves distributed upon it are more numerous, more exposed, and less intercepted or covered by callous parts. The heat of bodies, their general resistance, and their motion, are more perfectly felt when this general sensibility is most delicate.

With respect to the motion, the resistance and the heat of a liquid or fluid, particularly if the animal experiencing its action is immersed in it, the degree of the sensation also depends on the extent of the surface which the sensible body presents to the fluid; but something more is necessary for recognizing the forms of solids, particularly those that are small. In this case a very sensible skin must be extended over several small, divided, and moveable parts, capable of embracing the solid, by their different surfaces feeling its slightest inequalities, and tracing its most minute parts.

Thus the total perfection of the sense of touch depends on the quality of the skin, the number
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of its nerves, the extent of its surface, its freedom from insensible parts, and the number, flexibility, and delicacy of the appendices by which the animal can examine bodies.

As touch is the most important of all the senses, its degrees of perfection have a prodigious influence on the nature of different animals. From the investigation we are about to make, it will be found, that, of all vertebral animals, man has this sense most perfect. But among the invertebral animals the sense of touch improves in proportion as the others degenerate; and those which have no other sense, possess it so exquisitely that some of them seem even to feel the light.

Independently of the sensations of which we have spoken, and which have a direct relation to the qualities of external bodies, we experience others in the skin, particularly in the places where it is thinnest, and abounds most in nerves. These feelings are occasioned by the irritation which the motions, rather than the qualities or nature of bodies, produce upon the nerves, and belong more to the order of internal than external sensations: these are ticklings, prickings, and itchings.

Lastly, the skin performs a different function from that of touch, which consists in transpiration and absorption; that is to say, in the exhalation of a part of the elements of our fluids,

and in the inhalation of a part of the fluids which surround us.

This second kind of function does not belong to sensation. We shall therefore consider it in another place.

ARTICLE II.

Of the Skin and its Organization.

THE whole surface of the animal body is covered by an organ of a particular nature, named *skin*. It is a membrane applied to all the superficies which terminates the body, and its thickness varies according to the species of animals, and the different parts which it covers.

The organization of the skin appears to be essentially the same in all the classes of vertebral animals. The external differences which it presents are more or less connected with the developement of certain superadded parts, as we shall explain in the sequel. The structure of the skin cannot, however, be established in so general a manner in the animals that have no vertebræ, though it will be seen that its parts have some analogy to those found in red-blooded animals.

The skin of all the animals that have verte-
bræ

bræ is composed of four layers, more or less distinct, but which the anatomist separates, and may easily demonstrate. The lowest is called *dermis*, *cutis*, *corium*, or the *true skin*. The next is called *corpus papillare*, *tela mammillaris*, or the *villous surface*. The third, *corpus reticulare*, or *rete mucosum*. Lastly, the fourth, or most external, has been denominated *epidermis*, or *cuticle*.

We do not easily distinguish all these parts in animals that have no vertebræ. Some of the strata are more distinct, others less so. There are also some species in which we do not find the whole of them. These differences we shall point out more clearly in treating successively of each of the layers.

1. *The Cuticle.*

This layer, as we have already observed, is the most superficial. It is a transparent and insensible pellicle, which prevents the immediate contact of the nerves of animals with the medium in which they live. It is also continued into all the apertures of the body, and lines them internally to preserve them from the contact of air or water. Thus we find it on the eye, in the ears, the nostrils, the mouth, the anus, the vulva, &c.; but it is then described under different names, as has already appeared when we treated of the *conjunctiva* and the *membrane* of the *tympanum*, and as we shall shew hereafter in treating of the other organs.

The consistence of the epidermis varies with the medium in which the animal is immersed and obliged to exist. It is dry, and as it were horny in those that live in air; mucous, and more or less viscous in those that inhabit the water.

In the animals which are constantly subject to the drying action of the air, the cuticle appears variously folded, according to the parts of the skin to which it adheres. These folds form wrinkles, papillæ, circles, and spiral lines, which correspond to the elevations and depressions of the skin, but chiefly to those of the rete mucosum, and the scales when these last exist.

In general the epidermis is considerably the thickest on the parts which are most exposed to friction; as the sole of the foot, the palm of the hand, and all the other parts frequently used by animals, either in walking or in grasping other bodies.

In the furrows of the cuticle we observe the holes through which the hairs pass. These appear as conical elongations, or infundibula, which seem to have been forced outwardly by the hairs, to which they serve as sheaths.

In the animals which have scales, instead of hairs, the epidermis envelopes these parts in every direction, and is intimately attached to them.

In man the cuticle is generally very thin, with the exception of the parts which cover the sole

sole of the foot and the palm of the hand. Friction, or desiccation, either by heat or certain chemical agents, harden it considerably. They change it into a kind of horn, which blunts, and even totally destroys the sense of touch. We have very remarkable examples of this change in blacksmiths and dyers, and in men who walk bare-footed on burning sands.

The furrows of the epidermis form figures, with several angles, on the back of the hand; parallel and elongated lines on the palm and on the sole of the foot; arches, curves, and very singular, close and symmetrical spirals under the extremities of the toes.

The cuticle of the other mammalia is nearly similar to that of man. It is thin in proportion as the hairs that cover it are compact. That which covers the wings of the *bat* is also very thin, and has furrows which form many angles, like those we observe on the back of the human hand.

In the *porcupine* it is thin, and little distinct from the other strata of the skin, which is gelatinous.

We find the epidermis desiccated, and as it were scaly on the prehensile tails of the *beaver*, *rats*, *ondatra*, &c. and on the scales which cover the bodies of the *pangolius* and *armadillos*.

In the *elephant*, the *rhinoceros*, and the *hippopotamus*, which have the skin very thick and deeply furrowed, the epidermis, which is also thick,

thick, and covered with small plates that separate from it like scales, sinks into the different furrows. The cuticle of the sole of the foot presents a very singular structure. It is divided externally by deep depressions, nearly circular, with six or eight surfaces more or less regular, each of which contain an infinite number of small polygons much more irregular. This gives to the whole surface of the skin the appearance of shagreen. The epidermis detached from the animal, and examined by its internal surface, exhibits elevated lines corresponding to the furrows of the great polygons. It also presents others which are smaller, and correspond to the little polygons. The result of this disposition is a kind of net-work, in relief, of a pretty regular design, and resembling lace with large points.

The Cetacea have a very smooth epidermis, without any remarkable fold, and always covered with a mucous oily humour, which opposes the maceration of the animal during its residence in the water.

In birds the epidermis of the body is very thin, and formed of folds which correspond to the quincunces in which the feathers are arranged. That of the feet is smooth, shining, and formed of horny scales. It covers the different plates which we observe on the feet of the gallinæ and grallæ, of which we shall speak in the article on Scales. It is detached at
certain

certain periods of the year, chiefly in the moulting season.

In all the animals we have mentioned, the Cetacea excepted, the epidermis comes off in small pellucid scales, which give to the surface of their skin a mealy appearance. In some mammalia the cuticle is renewed at certain periods of the year, at the same time that they change their hair. In others it takes place more insensibly, and at all times as in man.

The epidermis of *tortoises* is not very distinct, except on the neck and limbs. It is analogous to that of the *salamanders*, which we shall describe presently. That which covers the scales of the back-shell and of the breast-plate is extremely thin. It is detached in transparent laminæ, the figure of which is exactly the same as of the horny plates.

In the *salamanders* and *frogs*, the epidermis is a mucous membrane, which covers the whole body, and which falls off in large pieces at several periods of the year.

The cuticle of *lizards* and *serpents* covers and entirely envelopes the scales. It is detached in a single piece like a sheath, at a certain period of the year: we observe, in these kind of exuviæ, even the portion of a sphere, which covered the transparent cornea.

In fishes, the epidermis, which covers all the body, the fins, and other appendices, appears always in a soft state; it sometimes seems a simple
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ple mucous substance enveloping every part of the animal's body. It is this mucous epidermis which renders it in general so difficult to seize the body of a fish. It is also detached in large pieces at certain periods of the year.

We shall see, in the sequel, when we treat of the internal tunics of the organs, into which the air, the water, or the aliments penetrate, that the prolongation of the cuticle which lines their internal surface, also becomes mucous, and that it has a considerable resemblance to the external epidermis of fishes.

We also find an epidermis in animals that have no vertebræ. Those which live in water have it commonly mucous, and of a very different thickness in the several species.

In the Cephalapoda it is nearly the same as in fishes.

In the naked Gasteropoda it very much resembles that of the salamanders and frogs.

In the Testacea in general we find an epidermis on the surface of the shells. In the ~~land~~ kind, as the *snails*, it is a dry pellicle, very easily detached, when the shell is, after the death of the animal, exposed to the action of the atmosphere, or plunged into boiling water. In the *anodontites*, the *muscles*, and other bivalves, we observe a similar epidermis, which envelopes the shell externally. This epidermis is always wanting on the surface of the projecting parts, on which the animal draws its shell along the sand,

sand, because it is there worn off. In some species of shells, the epidermis is thick and villous, and on this account it has been named *sea-cloth*. This is very remarkable in several species of the genus *arca* of Linnæus; and to express this peculiarity he has called one of them *pilosa*.

In all the Testacea, the epidermis which envelops the shell is continued to produce the pellicle which covers the animal; and it experiences the same change as that which is prolonged within the body of vertebral animals. It is thin and mucous on all the parts which are not exposed to the action of the ambient fluid. In the species of Gasteropoda, however, whose shell is concealed under the skin, and does not serve for a defence, the epidermis does not change its nature. We have examples of this in some species of *aplysia* and *scyllæa*, as well as in the animal which produces the shell, called by Linnæus, *helix balyotoidea*. (Lam. *figaret*.)

In the Crustacea and the insects, whether in the larva, nymphe, or perfect state, there is a real epidermis. This skin, however, when once dry and indurated, is not susceptible of extension, so as to accommodate itself to the growth of the animal. In proportion therefore as the insect increases in size, and at fixed periods in each species, but with respect to which the atmosphere appears to have considerable influence, the animal quits its epidermis, by drawing itself as it were out of a case. This is called the *moulting* period,

period, in effecting which the insect frequently employs several days, and which is sometimes mortal to it. The greater part of the caterpillars, of butterflies, and of bombices, change the skin seven times before they pass into the chrysalis state. The *bombyx-caja* quits in this manner the skin ten times. We intend to dwell more particularly on the subject of moulting in the Article on Metamorphosis, in the Lecture on Generation.

There is a very distinct cuticle in worms. It is easily separated from the skin in the *earth-worms*, which have been immersed for a few hours in spirits of wine, or macerated some days in water; it is a pretty solid pellicle, which may be removed in a single piece. In the worm called *sipunculus saccatus*, this epidermis is even entirely separated from the body, which is unconnected and floating within it, as if it were enclosed in a sack. The *leeches*, and some other worms, have the cuticle mucous, like that of the gasteropodous mollusca.

It is very difficult to ascertain the nature of the epidermis in Zoophites, or even to discover whether it exists in some of them. The *sea-stars*, the *urchins*, and the *actiniæ* appear to possess it.

The *medusæ* are covered with a pellicle, but so thin and transparent that it cannot be supposed to consist of strata. The other Zoophites, as the *polyps*, &c. have a mucous surface, the
softness

softness of which prevents us from distinguishing any membrane.

2. *The Rete mucosum,*

Is situated, as we have already stated, immediately between the epidermis and the villous surface of the skin. It is not membranous, but forms rather a mucous layer, the colour of which varies in different kinds of animals, and sometimes even in different parts of their surface. The colour of an animal's skin depends on that of this mucous substance, for in all those which have the skin coloured, if we remove the epidermis, it is found almost pellucid, and the cutis is also free from colour.

It appears that the influence of the solar rays determines, to a certain degree, the colour of the human skin; it is white in temperate countries, becomes more and more dark in warm regions, and, finally, becomes black in the burning climates of Africa and Asia. May not the cause of these varieties be referred to the different degrees of light which colours living bodies, by removing their oxygen, and developing the carbon and hydrogen which they contain? We find, indeed, that men who are exposed to the rays of the sun grow tawny, while those who inhabit subterraneous places undergo a change similar to the etiolation of plants, and become exceedingly white.

The colour of the mucous substance varies greatly in mammiferous animals. It appears to determine, as will be seen hereafter, that of the nails and hairs. It is even frequently found coloured in the cavities of organs, into which it is prolonged, as on the palate, the tongue, the ear, the conjunctive and nasal membranes of *apes*, *dogs*, *Ruminantia*, and *Cetacea*.

The rete mucosum of the mammalia is not often of a very vivid colour. It is however white on the cheeks of some *mandrills*; red, violet, and carmine on their hips and nose. It is of a fine silvery white colour on the belly of the *Cetacea*.

The rete mucosum is thickest in the last family of mammalia. In the *dolphin* and *porpoise* it is nearly half a millimeter thick on the back parts of the body and the head, which are of a black colour. We cannot compare it better, with respect to consistence and colour, than to the black produced by grease between the nave of a wheel and the axle-tree.

The mucous substance is little distinct in birds, and almost always white in all the parts covered by the feathers; but its colour on the feet, *ceræ*, and *carunculæ* of the head, is subject to variations.

On the tarfi and the toes, it is frequently black, as in the *ravens*, the *turkies*, some *ducks*, *swans*, &c.; grey, as in *hens* and *peacocks*; blue,

as in the *titmouse*; green, as in the *water-ben*; yellow, as in the *eagle*; orange, as in the *stork*; red, as in the *scolopax calidris*, &c.

The rete mucosum is black in the caruncle of *swans*, grey in the ceræ of the bill in a number of *parrots*, white in the chops of the *blue* *ra*, green in the ceræ of the bill of the *sparrow-hawk*, yellow in that of most diurnal birds of prey, red on the neck and cheeks of the *king* *the vultures*, &c. In general, it adheres to the skin; it is even difficult to separate it by maceration.

The colours of reptiles also depend on the presence of the mucous substance.

In the *tortoises*, for instance, the skin which covers the feet and the neck, is not only differently coloured by the rete mucosum, but the symmetrical spots which we remark on the scales are produced by the same substance. This we discover by dissection. The thickness of the skin greatly diminishes as it approaches the breast-plate and the back-shell. It passes below the scales which cover those parts, and which are themselves covered by the epidermis and the mucosum, the variegated colours of which form the spots which we observe through the transparent parts.

It is the same with respect to *salamanders* and *lizards*. Their mucous substance varies still more in colour; it is black, brown, grey, white, green, and yellow, red-orange, carmine, &c.

We also find a mucous substance under the scales of *lizards* and *serpents*, and its colours are exceedingly various.

Of all vertebral animals, however, fishes are the most remarkable for the brilliant and metallic colours which their rete mucosum exhibits. We find in them gold, silver, and copper, tin, lead, and even all the tints which these metals assume in different degrees of oxydation. But as the description of these colours is the province of Natural History properly so called, we wish merely to point out in this place that they are produced by the mucous substance which adheres closely to the internal surface of the scales, and with which it is frequently removed.

Most mollusca have a rete mucosum below their epidermis.

In the Cephalopoda it is most commonly of a blue or red colour, but it forms a very thin layer.

That of the Gasteropoda varies considerably, as we may observe particularly in the *slugs*. It is thick and viscous, but dissolves completely in water.

May not the substance of the shell itself be really analogous to the rete mucosum, though the term *mucous* cannot be applied to it? I am very much inclined to believe that this is the case.

The calcareous shell is in fact found immediately under the epidermis; and when some of its

its parts are removed, it is a kind of crust without any apparent organization, and not a membrane. It is produced by successive strata. Finally, it is coloured, and its shades are infinitely various.

In the Crustacea, the mucous substance is also represented by the calcareous crust situated below the epidermis. Its colour is usually a dark-green, but sometimes red, white, or black. Alcohol, acids, and particularly the action of fire, change the green colour to a red, which is frequently very brilliant. This we observe every day at our tables in *cray-fish*, *lobsters*, &c.

In insects, in the larva state, we observe between the epidermis and the muscles, a layer of mucous matter, the colours of which vary infinitely in the different species. In *caterpillars*, and in the larva of some Hymenoptera, this substance is most remarkable for its colour. It gives to their bodies the most beautiful and lively tints, the shades and symmetry of which are truly admirable. White, purple, violet, blue, green, yellow, aurora, black, &c. &c. are distributed in the most regular and striking manner.

We are also of opinion that the mucous matter dried or mixed with the horny substance, produces the colours exhibited by perfect insects, for when the Lepidoptera are in their rymalid state, the small coloured scales which afterwards ornament the wings of the perfect

insect, are then found in a mucous state, similar to that which we observe in the skin of *caterpillars*. The colours of *spiders* are also the effect of the rete mucosum; we find it under the skin; it has the appearance of small glandular points, the shades of which vary considerably. But in the *Coleoptera*, and several other orders, the colours of the skin are diffused through the horny crust, nearly in the same manner as those of the *Crustacea*, through their calcareous shells.

The rete mucosum cannot be distinguished, except in a small number of species of *Zoophyta*; and it is even so thin, that we cannot separate it from the skin, as may be observed in some *sea-stars* and *actiniæ*. It appears to be confounded with the calcareous shell which forms the habitation of several other genera. This may be observed in some species of *urchins* and *corallines*; and in the *Ceratophites*, and a number of *Lithophites*.

3. *Corpus Papillare, or the Villous Surface of the Skin.*

Anatomists have given this name to that part of the skin which is situated between the cutis and the rete mucosum. It is not membranous like the epidermis, but is a surface produced by the aggregation and approximation of a multitude of small tubercles of different shapes, which are supposed to be formed by the last extremities

trémities of the cutaneous nerves ; they are, therefore, named *nervous papillæ*.

Though the figures of these tubercles are very different, their structure is nearly the same : it is easily exhibited, by macerating them for some days in water ; we then observe that each tubercle consists of a collection of fibrils, united at their base, nearly in the manner of hairs in a pencil. Sometimes the fibrils of the center are longer than those of the circumference, and then the papilla is of a conical figure. Sometimes they are nearly of the same length, and in that case it is flat.

The sense of touch resides particularly in these papillæ : we find them, therefore, in the greatest number, and most conspicuous, on the tongue, the lips, and the extremities of the fingers.

In man, the papillæ are particularly remarkable on the soles of the feet, and on the palms of the hands ; they are situated close together in a very compact manner, and distributed in lines corresponding to those we observe externally, and of which we have already spoken in treating of the epidermis. Those under the nails produce a villous surface, the compact fibrils of which are all directed obliquely towards the extremity of the fingers. The fibrils of the lips are disposed in the same manner, but they are still more delicate, longer, and closer to each other.

It is nearly the same in all other mammifere-

rous animals; but the papillæ are more developed, in proportion as the parts to which they belong are employed in touch. In the *mole*, the *shrew*, and the *hog*, the nervous papillæ are very visible on the snout; they form tufts, consisting of very close fibres. We find them also on the proboscis of the *elephant*, and we have observed them very distinctly on the tail of the *Cayenne opossum*; it is probable that they exist in the same manner in all prehensile-tailed mammalia. We have not observed them on the skin of the *dolphin* and *porpoise*.

Birds have no distinct papillæ, except under the sole of the foot, and the toes; they are very close set tubercles, arranged in parallel lines. We easily demonstrate them on the feet of poultry, when the epidermis is removed by the action of fire. We also observe them on the membrane which unites the toes of the Palmipedes.

Reptiles resemble birds with respect to the papillæ; we find none, except under their feet; they are very thick, and projecting in several species of *lizards*, and particularly in the *camelion*. We cannot distinguish them in the *sea-tortoises*, which have the feet in the form of fins. They do not exist in *serpents*, or at least have not the form of papillæ.

We have observed nothing under the skin of white-blooded animals, which can be regarded as nervous papillæ. In the cephalapodous mollusca, however, we have seen some nervous
filaments

filaments in the small globules, which appeared to us glandular, and with which the skin is covered. In the other mollusca we can trace some nervous filaments into the substance of the skin, but we have never observed them to form papillæ.

4. *The Cutis.*

This is the name given to that part of the skin which is situated most internally. Anatomists have developed its structure in a very distinct manner, by the means of certain preparations, and particularly by maceration in water. They have demonstrated, that it is composed of a tissue of gelatinous fibres, which cross each other in every direction, and which are so interwoven that the whole may be compared to felt: among these fibres we discover a great number of fine ramifications of nerves, and arterial, venous, and lymphatic vessels, to which we shall return in a particular article.

The organization of the cutis is such, that the fibres, which compose it, are capable of elongation and extension in every direction; its extensibility was necessary to give to the surfaces of animals the power of resisting the physical action of other bodies.

Manufacturers have profited by this property of the skin, to prepare it in certain ways, which fit it for different purposes, in which strength and flexibility are necessary, and in which a great friction is sustained; this constitutes the
art

art of the currier. The fibres are likewise approximated, or separated, in order that the leather may be applied to various uses ; and this is the foundation of the arts of the tanner, skinner, parchment-maker, morocco-maker, &c.

In man, the cutis is from two to three millimeters thick in certain parts of the body, as in the dorsal and lumbar regions ; but it is only half a millimeter on the arms and the body. By maceration, and the processes used by skinners, we observe that the fibres, which enter into its composition, are long, fine, and very solid ; but united in a lax manner.

In mammiferous animals, in general, the cutis is thickest on the dorsal, and thinnest on the ventral region.

It is much thinner in birds, than in the mammalia. In some families, however, it has a considerable consistence, particularly in birds of prey, and in the anseres. It is exceedingly thin, even proportionally considered, in some species of *titmouse*, and the genus *motacilla*.

Reptiles, which have the body unfurnished with scales, or only partly covered by them, have a very compact and dense skin. We have an example of this in the *tortoises*, *salamanders*, *frogs* and *toads*. In the two last genera, in particular, the cutis is rendered remarkable, by not adhering to the body in all its points, as in the other animals, in which it is intimately united with the cellular substance. In those
genera,

genera, however, it adheres only at the edges of the mouth, in the middle line of the body, the arm-pits, and the groins. In all the other parts, the body is free within the cutis, which encloses it like a sac.

The cutis of *lizards* and *serpents* resembles that of fishes.

In this class of animals, we find a very tenacious cutis below the scales; but it is intimately attached to the muscles, even much more closely than in the other classes, and is very thick in the *sturgeon*, the *sharks*, the *rays*, the *eel*, &c. on the contrary, it is thin in fishes which have large scales, as the *carps*, *breams*, &c.

We have not observed a real cutis among the invertebral animals, except in the *cuttle-fish*, and the other Cephalapoda; it is applied almost immediately to the muscles, by the means of a very dense cellular substance; it is itself of a very coriaceous nature, and not easily lacerated; its fibres are very slender.

In the other invertebral animals, we find no part that can be compared to the cutis. There is, indeed, a pellicle below the shell of the crustacea, but it is fine, transparent, and has very little consistence. In insects in the larva state, the skin, which they cast off in moulting, is of the same nature and the same thickness as that below it, and which is destined to succeed it. Even the envelope of *chrysalides coarctate*, as those of the Lepidoptera and Diptera, cannot

cannot be regarded as cutis: it is rather a kind of horny epidermis. Finally, in the perfect state, we find no part of the teguments of insects that can be compared to the cutis. The same observation applies to the worms and the Zoophites.

ARTICLE III.

Of the Muscles of the Skin, or the Panniculus Carnosus.

IN the preceding Article, we have explained the nature and the organization of the different strata of the teguments. We shall now proceed to consider the motions of which the skin is susceptible, and the organs by which they are produced.

In man, the skin has very little motion; the muscles inserted into it have, therefore, very little force: they form three pairs; two of these muscles are particularly destined to move the skin of the forehead and the head; the third acts on the teguments of the neck and the cheeks.

All the space comprised between the occiput and the superior part of the orbits, is occupied immediately below the cutis, by a digastric muscle, principally aponeurotic, and which is
named

named *occipito-frontalis*. The fleshy fibres are very short, and situated at the two extremities of the large aponeurosis, which forms a kind of cap to the cranium. The anterior fibres are attached to the skin below the eye-brows: the posterior are inserted into a transverse line above the occipital bone: their other extremity passes under the aponeurotic cap, to which they are fixed. These muscles are more distinct in some subjects, than in others; they raise the eye-brows, corrugate the skin of the forehead, and produce those transverse wrinkles, more or less parallel, which we observe above the brow.

Immediately below the anterior fleshy fibres of the *occipito-frontalis*, and in the line which corresponds to the eye-brow, we find some other fleshy fibres, which arise from the nasal eminence of the *os frontis*, and are inserted partly into the skin of the eye-brow, and partly into the fibres of the *occipito-frontalis*, with which they are covered: this small muscle is called the *corrugator supercilii* (*fronto-supercilius*;) it opposes the effect of the *occipito-frontalis*, and approximates the eye-brows, and thus corrugates the skin above the root of the nose.

Finally, the third pair of cutaneous muscles, (*thoraco-facialis*) in man, occupies all the anterior part of the neck; they form a kind of fleshy membrane, situated immediately below the skin; it originates, upon the anterior part of the breast, by slender and very distant fleshy fibres

fibres in the cellular substance, which covers the great pectoral and deltoid muscles, and extends to the lateral parts of the cheeks; it is there partly attached to the lower jaw, and partly to the zygoma; these muscles are exceedingly thin, and loosely connected in the inferior part of the neck. They become thicker, in proportion as they contract.

It is difficult to determine the action of these cutaneous muscles; they act on the mouth by their union with the muscles of the lips; they have also great influence on the expression of the countenance. They produce very remarkable wrinkles in the teguments of the neck and the chin.

There are also some muscular fibres under the skin of the scrotum in man, which are denominated the *dartos*; but these fibres are very slender. They vary considerably, and, strictly speaking, do not constitute a muscle: they are destined to corrugate the skin of the scrotum.

In all the other mammalia, we find these cutaneous muscles; those of the head are commonly less conspicuous, but that of the neck is most strongly marked: there is, besides, a particular muscle, which extends under all the skin of the belly, and even under the thighs, and is inserted into the humerus.

Apes and *dogs* have an occipito-frontalis; it is also very thin, but its fleshy fibres are proportionally longer than the human. We find,
besides,

besides, under the skin of the face, some fleshy fibres, which perform the action by which these animals wrinkle the lateral parts of the cheeks and the nose.

The cutaneous muscle of the neck in *apes* is connected to the skin by a very compact cellular substance: it is prolonged over the face, and unites with the fibres we have already mentioned.

In *dogs*, we observe only some very slender fleshy fibres on the neck.

The cutaneous of the belly also adheres very closely to the skin in these animals; its fibres cover the thorax and abdomen, and all unite below the arm-pit, where they are inserted by one or two tendons, along with that of the great pectoral muscle, under the head of the humerus. This muscle has the same insertion in all the mammalia; it assists in the motions of the arms, and may be named *dermo-humeralis*.

In the *Quadrumana*, *Cherioptera*, and male *Sarcophaga*, we also find muscular fibres in the skin of the scrotum. They are even proportionally more conspicuous in the *bat*, than in man.

In the *raccoon*, the dermo-humeralis is likewise a very powerful retractor of the prepuce; it forms a bundle of fibres, of the breadth of two fingers, attached to the prepuce, and describing an oval, with the bundle of the opposite side: the remainder of the muscle, which covers the belly, is very thin. Anteriorly, the

muscle is attached to the humerus by two distinct slips.

The cutaneus colli in the *marmotte* very much resembles that of man : below it, however, we find another thicker muscle, which forms, as it were, a lining to the first, but proceeds farther up ; it extends to the lateral parts of the head, and even to the face and the muzzle.

The dermo-humeralis occupies the whole of the back, from the origin of the tail, to the posterior point of the trapezius. The part on the belly arises from the pubis, the groin, and the thighs : all the fibres unite below the armpit, where they form two tendons, one of which is inserted with those of the latissimus dorsi and teres major, and the other with that of the pectoralis major.

There are very few variations in the other species of mammalia. In almost all of them there are some muscular fibres under the skin of the male genital parts, particularly in those that eject their urine by squirts.

We find a cutaneous muscle even in the *dolphin* ; it arises from the lateral parts of the body, and terminates in the os humeri.

As the *European hedge-hog* presents a very complicated and curious organization in the muscles of the skin, we shall here give an abridged description of them.

It is necessary, in the first place, to observe, that those muscles, being attached to the skin,
change

change their situation with it, and that they are therefore fixed with respect to their points of attachment only. We must then suppose the animal placed in certain positions, in order that the parts described may be more readily found.

Let us suppose the hedge-hog rolled up as in the position the animal assumes for defence. All the body is then enveloped under the skin, by an oval-shaped sac, composed of fleshy and concentric fibres.

These fibres adhere closely to the skin, and even to the root of the spines which cover it, and it is difficult to detach them with instruments. The fleshy purse they form is thickest at the margin of its aperture, which corresponds to the belly, at which place they form a kind of sphincter or muscle with orbicular fibres.

When the body of the hedge-hog is elongated, as in standing or running, the figure of this muscle is completely changed. It is situated on the animal's back, where it forms an oval, the middle part of which is very thin, but the circular margin considerably thicker, and more elevated. Several accessory muscles arise from different points of the margin.

Towards the head, or at the anterior extremity of the oval, we observe two pairs of accessory muscles; one has its origin in the middle line, and is inserted into the bones of the nose; the other, which arises more externally, appears to be confounded with the exterior or-

bicular fibres, and is inserted anteriorly into the lateral parts of the nose and intermaxillary bones.

Another pair of muscles arise from the posterior extremity of the oval. They are of a broad pyramidal form, and are likewise continued with the external orbicular fibres. The tendinous point of each is inserted laterally near the end of the tail.

There are also some other sub-cutaneous muscles, situated towards the belly, or below the great orbicular muscle.

When the skin of the belly is removed, we readily perceive three distinct portions of fleshy fibres.

The first is situated under the throat, and corresponds to the cutaneus colli. It comes from the top of the breast under the skin, and is inserted on the lateral parts of the head, near the ears. The portion of one side unites to its correspondent by a middle line, which is made of fat.

The second comes from the middle line of the sternum; it takes an oblique direction, becoming thicker and narrower above the shoulders, as it proceeds to join the edge of the great orbicular muscle.

The third ventral portion, which is still more slender than the two former, extends over the whole surface of the abdomen; it arises from the circumference of the arms, from the lateral parts

parts of the tail, and from the tops of the thighs : upon reaching the ribs, it divides. The internal portion, which is the broader of the two, passes under the arm-pit, and is inserted into the internal side of the upper end of the os humeri. The external is prolonged laterally, and unites with the great orbicular cutaneous, towards the neck.

These are the muscles of the superficial layer: there are still some others, which are appendices of the former, and are situated under the muscles of the back.

One arises from the head, where it is attached, on both sides, to the posterior edge of the external meatus auditorius. It is lost posteriorly in the anterior point of the orbicular muscle.

Another small bundle of fleshy fibres arises from the last cervical processes, and is lost in the cutaneous of the back.

Lastly, below the great orbicular muscle, we observe some transverse fibres, which form a very thin layer. The anterior are attached to the internal and upper part of the humerus: the posterior, to the external bundle of the third ventral portion.

Let us now consider the use of these muscles.

The animal, when rolled up like a ball, is enveloped by the orbicular muscle. To preserve this position, it is sufficient to contract the marginal fibres, which are very strong, and

which, in closing the purse so as to cover the belly, have the effect of a sphincter.

When the animal wishes to return to its ordinary posture, it unrolls itself thus: the middle fibres of the oval contract; the external fibres at first relax, and leave the belly and the feet free; all the circular fibres then contract together, and gather up towards the back.

By this general contraction, the accessory muscles are rendered fixed, and capable of contracting. The anterior move the head upward, and extend it towards the back. The posterior raise the tail.

Those of the deep-seated layer elevate the head and the neck; the animal is then enabled to walk.

If the approach of danger induce the hedgehog to roll itself up, the animal accomplishes this purpose in the following manner:

The orbicular cutaneous relaxes, and the muscles of the head and the neck elongate the oval; the deep transverse fibres attached to the external portion of the ventral cutaneous, render it broader.

Every thing now yields to the impulse: the flexors, and the cutaneous of the neck and breast, draw the head towards the belly; the cutaneous, and muscles of the abdomen, bring the tail and the thighs towards the head; the flexors of the limbs contract; the great orbicular muscle then descends

descends on the ribs, contracts obliquely, and thus, assuming the shape of a purse, retains the animal in a globular form.

The cutaneous muscles of *armadillos (dasypus)* are not so strong, nor so complicated as those of the hedge-hog, though these animals have also the faculty of rolling themselves up.

The great dorsal cutaneous is thickest at its ventral margins, by which it strongly adheres to the fold that unites the skin of the abdomen with that of the back; it is fixed to the skin of the groins and arm-pits: it also detaches some slips, which are inserted into the head and the tail; but its fleshy fibres are very slender. A certain number of fibres are sent off at different spaces, and inserted into the anterior edge of each of the osseous bands which cover the animal.

The cutaneous muscles of the belly are also very slender; they furnish some fleshy fibres to the penis: and the bundle which these fibres form, very much resembles that which we have observed in the *raccoon*; but it is less thick.

The cutaneous colli exists, but it is exceedingly small; it is prolonged under the scales of the face.

Among birds, these muscles are more conspicuous in certain species, particularly when the bird has the power of moving at pleasure, the feathers of the crest, neck, or tail, as the *hoopoes*, *cockatoos*, *herons*, &c. They are

very easily dissected in the *goose*, and from that bird we shall describe them.

The ventral cutaneous arises from the seventh and eighth ribs, by two fleshy digitations, like the *ferratus magnus*; it is broad and flat; it proceeds obliquely forward and upward towards the scapular articulation of the humerus, and is inserted into the skin, above the shoulder joint.

There are also some fleshy fibres on the external lateral part of each of the great pectoral muscles. In the substance of the skin, immediately above the arm-pit, these fibres are confounded with the tendon of the *pectoralis major*.

Immediately above the broad flat part of the bone of the pelvis, between the two ilei, we observe two small fleshy layers below the skin: the short, and apparently papillated fibres of these layers, act on the feathers of that part of the pelvis, and erect them.

We also remark along the skin of the neck, some longitudinal muscular fibres, which move that part; they form two distinct layers, particularly on the sides.

There is no cutaneous muscle on the trunk of *frogs*, because the skin does not adhere to that part of their body. Under the throat, however, we find some fibres, which are attached to the margin of the jaw, and inserted into the cellular substance that unites the skin to the origin of the breast.

In *tortoises*, the cutaneous colli is very visible,
and

and seems to be formed of two parts; it is extended from within the concavity of the lower jaw, to the bottom of the neck, at the anterior part of the breast-plate. A middle cellular line unites it with the muscle of the other side; it takes its origin from the transverse processes of the cervical vertebræ. Being spread over all the muscles of the neck, it serves as a girdle to them; in its lower part it is perforated by the sterno-mastoideus, which, as we have already observed, arises from the lateral parts of the breast-plate.

On removing the skin of spinous fishes, such as the *carp*, we find some muscular fibres adhering intimately to it: they are divided into two portions, by a longitudinal line, which corresponds to the situation of the vertebral column. We here observe impressions made by the tendons, inserted in the skin; they describe curves, the convexity of which is towards the tail. These are the only parts that can be regarded as cutaneous muscles in fishes.

In the animals without vertebræ, that have soft bodies, almost all the muscles may be considered as cutaneous; for the greater number are attached to that integument. But as they are also employed in progression, we have described them among the Organs of Motion.

ARTICLE IV.

*Of the Glands of the Skin, and the Subcutaneous Fat.*1. *The Glands.*

THE surface of the skin is spontaneously bedewed with substances, which appear destined to preserve it from the action of the surrounding elements, and which vary according to the nature and habitation of different animals.

This humour is unctuous in man, and other warm-blooded animals; it is a kind of fat, which would gradually accumulate on the skin, if we did not take care to remove it.

In the cold-blooded animals it is of a viscous or gelatinous nature, and does not dissolve in cold water: these animals have it in the greater abundance, in proportion as they reside more constantly in the water, and have their bodies less completely covered with scales. It appears to be a supplement to this last kind of armour. Fishes that are destitute of scales, therefore, as rays and sharks, have a great quantity of this fluid, compared with those that are covered with large scales.

Among reptiles, those that have scales, as snakes and lizards, have the skin almost dry: but those with naked skins, as salamanders and
frogs,

frogs, have the surface of the body always copiously lubricated with viscous matter.

Toads and *salamanders* have even the power of augmenting the secretion of this liquor, and of making it exude like a dew through the pores of the skin.

Among the animals that have white blood, we find that most of the mollusca produce a glutinous liquor, which lubricates the whole of their skin; they even throw out a considerable quantity of it, when they are in the least danger. This is particularly remarkable in *snails*, &c. In those that have a hard and scaly skin, however, nothing similar is exuded, and their excretions take place only at particular parts of the body.

The same animal does not produce the same kind of substance in all the parts of the skin. In man, for example, there are three of these excretions, besides perspiration.

A very subtil oil transudes through the pores of the whole skin, and prevents, for some time, pure water from spreading upon it. This matter also appears upon the hair of the head, and other parts of the body, and at last gives them a greasy appearance, if they are not frequently cleaned.

A kind of ointment is produced in certain parts, and particularly at the roots of the hairs in the arm-pits and the hams, &c. from small follicles, which are visible to the eye: this
matter,

matter, in hardening, attaches itself to the skin, and produces a sort of scales, which are removed by water and friction.

Lastly, there are glands, the apertures of which are very visible in certain places, that furnish a concrete ceruminous matter. This substance may be compressed in the form of small worms: these glands are found on the sides of the nose, behind the ears, under the eye-lids, around the nipple, on the perinæum, and in the groin: they may also be observed scattered almost every where, except, perhaps, on the palm of the hand, and the sole of the foot.

We may include, in the last kind, that thick fetid matter, which accumulates in lumps between the glans of the penis and the prepuce, and beneath the nymphæ; and also that which covers the edge of the anus.

We are unacquainted with the organs which produce the first kind of humour; it is, perhaps, a simple exhalation of the fat, which always exists in a certain quantity under the skin.

The follicles, which produce the second kind of ointment, are very small, and round, or oblong. Their excretory canals are small and twisted.

The third kind of ointment is produced by glands which are named *sebaceous*, and which are sometimes compound.

The substances which anoint the skin of quadrupeds, are similar to those which we find
on

on our own : some have them collected in large clusters; on certain parts of the body, as for example in the groin. The glands, or particular follicles, do not appear conspicuous in the skin of the Cetacea ; an oily fluid exudes from the whole of its surface, in such abundance as to render it every-where smooth and slippery.

In birds, the sebaceous glands are difficultly seen, and situated more deeply under the skin. On the rump there is a conglomerate gland of a particular structure, from which they express an oil, which serves to imbue their feathers. We shall describe this gland when we treat of Excremental Secretions. At the same time, we shall notice several other glands peculiar to certain kinds of quadrupeds, as those which produce *musk*, *civet*, *castor*, &c.

The cutaneous glands are more visible in cold blooded animals, than in the preceding.

The *salamanders* have several glands ranged along the back, which form elevations, or lumps on the skin.

The *toads* have them scattered irregularly, on the whole surface of the body ; we observe, in particular, two which are very large, behind their ears ; these glands produce an acrid humour, which is a poison to very small animals.

In *lizards*, we observe a very regular row of small pores, which also yield a viscous humour.

But the pores which transmit the viscous matter to the skin, and the sources which produce

duce it, are no where so easily observed as in the *rays* and the *sharks*.

On the superior and inferior surface of the body, in those fishes, we find a great number of very large pores, which are the orifices of an equal number of transparent excretory vessels. In the *sharks*, these vessels are as thick as the tube of a quill; they proceed from certain centers, in fasciculi, which are not divided into branches; these centers are more or less numerous according to the species, and the gelatinous humour they contain appears to be formed within them: the centers, however, do not resemble glands; we observe in them only a cellular texture, filled itself with the same humour, and to which a great number of nerves are in particular distributed. In the *ray*, there are two principal centers, situated towards the sides of the mouth. The *tope* (*squalus galeus*) has only one in the snout. We shall return to this subject in the Article on Secretion.

In osseous fishes, the viscous liquor chiefly exudes through pores situated along the furrow, which extends longitudinally on each side of the body, and is called the *lateral line*: these foramina are the orifices of an equal number of small tubes, which communicate with one large tube situated behind this line, throughout the whole of its length. This great vessel reaches to the head, and is there divided into several branches, which spread over both jaws, and two
of

of which unite towards the upper part of the snout. The *rays* and *sharks* have also these large viscous vessels on the head, independent of the numerous small vessels which we have just described, and which are peculiar to them.

We observe these vessels, and the pores, which are the orifices of their small branches on the head, more distinctly in the *chimæra monstrosa*, than in any other fish. The pores are also very visible in the *common pike* (*esox lucius*), and the *sea pike* (*esox bellone*).

2. The Adipose Substance.

A cellular web more or less firmly unites the skin to the flesh; this membrane exists in almost all animals, except *frogs* and *toads*, in the greater part of which the skin adheres closely only in some parts of the body, and is connected with the flesh of the other parts merely by vessels and nerves.

We also find in birds, and principally under their axillæ, large portions of skin, which adhere only in a very loose manner to the flesh. In consequence of this structure, the air is admitted into the vacant space.

If we may believe Sparman, the *ratel*, or *honey-eating badger of the Cape*, (*viverra melli-vora*, Lin.) presents a similar disposition.

The subcutaneous cellular membrane is usually filled with fat, the quantity and consistence of
which

which varies according to the species, and the state of each individual. Every one knows, that the *bog* has the fat thicker, and more uniform, than other quadrupeds, in which it is, therefore, called lard.

The Cetacea have still a thicker coat of lard than the *bog*, but their fat is so liquid, that it runs off in the form of oil, without being expressed.

Animals, in which the subcutaneous fat is very abundant, have the sensibility of the skin greatly diminished.

In the cold-blooded animals, there is, strictly speaking, no subcutaneous fat. Sometimes only we find the inner surface of the skin moistened like the rest of the body by an oleaceous fluid. This we observe, for example, in the *salmon* and *trouts*. At other times we find substances of a very different nature. The *moon-fish*, for example, has, under the skin, a layer two or three fingers breadth thick, of a fat substance, apparently like lard, but which presents all the chemical characters of albumen.

The use of these different substances placed under the skin, appears to be to weaken the impressions of blows, or other external shocks, and to diminish their effect upon the flesh. But the fat, in general, has several other uses; it serves to preserve the flexibility of all the parts between which it is interposed, and, in particular, forms a kind of magazine of nutritive substance,

substance, which may be absorbed, and conveyed again into the blood.

This is chiefly remarkable in animals which exist for a certain period, annually, without food: as those that sleep during winter, caterpillars, when they pass to the chrysalid state, &c. Such animals do not fall into these lethargies, until after they have accumulated a great quantity of fat, which is found to be exhausted when they awake.

There are particular reservoirs for this substance, which we shall describe in the *bears*, *dormice*, *marmottes*, *caterpillars*, &c. when we come to the Article on Nutrition.

ARTICLE V.

Of the Fingers and Toes, and of their Structure relative to the Sense of Touch.

IN Lectures IV. and V. we described the number, form, and use of the bones and muscles of the members, and of their extremities, with respect to their use in motion; we are now about to consider these parts in another point of view, namely, with relation to the organ of touch.

The fingers are particularly intended to procure us a knowledge of the forms of bodies.

Two circumstances tend to perfect or diminish

nish the faculty of touch : 1. The division of the hand and foot into fingers or toes, more or less numerous, more or less long, distinct and moveable. 2nd, The form of these fingers or toes, and the nature of the teguments which cover, arm, or protect them. These considerations form the subject of the present article.

The organ of touch is more perfect, in proportion as the hand is divided into distinct and moveable fingers : man, therefore, possesses this sense in a very eminent degree. *Monkies*, indeed, have the hand organized like that of a man ; but, as we observed in treating of the muscles, Vol. I. p. 335, &c. they cannot move the fingers separately, as they have no proper extensor or flexor muscles : besides, their thumb is shorter, and cannot be so easily opposed to the other fingers. It is, however, on this opposition of the fingers that the faculty of seizing the most minute objects, and of distinguishing their slightest eminences, depends. But if the hand of *monkies* be less perfect than that of man in this respect, they have a more advantageous organization of the foot, the toes of which are longer and more moveable.

In man, and in the greater number of *Quadrumana*, the fingers are slender, rounded, and covered by a compact skin, on which numerous nervous papillæ are disposed in a very regular manner : their extremity is covered by a nail, on the superior part only : this nail is flat, or
femi-

femi-cylindrical : only the *sagouins* (*simia rosalia*, *jacchus*, &c. Lin.) have the extremity of the toe inclosed in a horny and pointed nail, resembling that of the Sarcophaga.

In the Cherioptera, the fingers are not capable of grasping solid bodies, because they are all inclosed between two fine membranes. They therefore do not possess, in a high degree, that part of the sense of touch which serves to ascertain the forms of bodies ; but the extensive surface which the membranes present to the air, fit them for receiving such delicate impressions of resistance, motion, and temperature, that some authors have been induced to ascribe a sixth sense to these animals.

Spallanzani had observed that *bats* blinded, and afterwards set at liberty, could, notwithstanding their total deprivation of sight, conduct their flight through subterraneous passages without striking against the walls ; that they even turned exactly as the most complicated windings required ; that they discerned the holes in which their nests were placed ; and that they avoided cords, lines, and other obstacles which had been placed in their way.

Spallanzani then endeavoured to ascertain by what sense these animals directed their motion.

It was not sight, since that organ was entirely destroyed ; it was not hearing, for the ears of several individuals had been completely stopped ; it was not smell, for in others he had taken the

precaution to shut up the aperture of their nostrils.

He concluded therefore, that *bats* possess a sixth sense, of which we have no idea. Citizen Jurine has made other experiments, which tend to prove that it is by the ear they guide their flight ; but it appears to us, that the operations to which he subjected the individuals he deprived of the power of directing their motions were of too severe a nature, and that something more was done than merely preventing the animals from hearing. It appears to us also, that the nature of their organ of touch is sufficient to explain all the phænomena *bats* present.

The bones of their metacarpus, and the phalanges of the four fingers which succeed the thumb, are excessively elongated. The membrane which unites them, presents an enormous surface to the air : the nerves which are distributed to it, are numerous, and minutely divided ; they form a net-work very remarkable for its fineness, and the number of its anastomoses. It is probable that, in the action of flight, the air, when struck by this wing or very sensible hand, impresses a sensation of heat, cold, mobility, and resistance on that organ, which indicates to the animal the existence or absence of obstacles which would interrupt its progress. In this manner blind men discern, by their hands, and even by the skin of their faces, the proximity of a wall, door of a house, or side of a street, even
without

without the assistance of touch, and merely by the sensation which the difference in the resistance of the air occasions.

The toes of the posterior feet in *bats*, are similar in their structure to those of the other *Sarcophaga*.

Notwithstanding the *Plantigrada* have the fingers very short and little moveable, and generally five in number, the sensation of touch is thought to be somewhat more perfect than in the *Carnivora*, because the whole sole of their foot is free from hairs; and as the contact with the bodies which they touch is more immediate, the sensation must be stronger and better perceived.

The *mole* has the hand greatly enlarged, and all the fingers united as far as the nail.

The *Pedimana* come naturally after the *Plantigrada* with respect to the presumed perfection of touch, as their great toe is separate from the other toes. This renders their posterior foot a kind of hand; the toe is proportionally very thick, elongated, moveable, entirely deprived of the nail, and enlarged at its free extremity.

The *chestnut coloured*, or true *orang outang*, is the only animal, besides the *Pedimana*, that has a separate great toe without the nail.

The *Carnivora* walk on the extremity of their toes, which are short, and all placed in the same direction, and are therefore much less favoured to the sense of touch, but they are in general compensated by that of smell. The greater

number have the last phalanx inclosed in a cutting nail. In the *cat* and *civet* genera, this phalanx bends back, and cannot be employed as an organ of touch whilst the animal walks.

Among the Rodentia, the *hares*, *squirrels*, and *rats*, which walk on the four feet, but on the extremities of the toes, and which have the last phalanges only separate from each other, have an elongated conical nail which envelopes all the free part of the toe. Some *cavies*, and the *porcupine*, have almost all the toes inclosed in hoofs like those of hogs. The *aye-aye*, (*sciurus Madagascariensis* Lin.) is particularly remarkable for the division of the toes of the fore feet. All the phalanges are greatly elongated, particularly those of the middle toe, by means of which the animal picks insects from under the bark of the trees. This is also the only animal among the Rodentia which has the great toe separate, and opposeable to the others.

Lastly, the *kangaroos* and *jerboas*, which use chiefly the hind feet in progression, have the fore feet divided like those of rats, and armed with pointed nails; but the posterior feet have the toes enveloped in hoofs.

The Edentata in general have the toes united by the skin as far as the nails, some of them even, as the *sloths*, walk only on the convexity of the nails, which bend under the sole of the foot. The *Cape ant-eater* has flat and very broad nails. Several *armadillos* have them almost in
the

the form of hoofs. In all these animals the toes vary from four to two, and are capable of no motion except extension and flexion. This disposition arises from the deep pulleys in the articulations of the phalanges.

The *elephant* and the *rhinoceros* have all the toes united by a thick and callous skin. They are only distinct externally by the number of hoofs which are placed on the edges of the foot.

The *hippopotamus*, the *tapir*, and the *bogs*, have the toes more separated; but they walk on their extremities only, which are enveloped in hoofs.

All the Ruminantia, without exception, have only two toes, covered with hoofs of a triangular form, on which they walk. The inferior surface, which touches the ground, is the most soft, and appears tuberculated. The external is convex and smooth. The third surface, or that which is next the other toe, is a vertical plane. The *camel* only differs a little in the form of the hoof, which is small, more regularly triangular, and prolonged inferiorly by a piece of horn which invests all the sole of the foot.

Finally, in the Solipeda there is only a single toe, terminated by a semi-circular hoof, on which the animal walks.

Before we conclude this article on the division of the members in Mammalia, we shall notice some dispositions relative to motion, but which have an influence on the sense of touch.

We have already pointed out one of these peculiarities in the Cherioptera. Among the Sarcophaga, the *otters*, the *seals*, the *didelphis mermia*, and one species of *shrew*; and among the Rodentia, the *beaver*, the *ondatra*, &c. which swim and dive frequently, have all the feet palmed, that is to say, their toes are united by a membrane.

Lastly, in the *morse*, and in the Cetacea, we do not distinguish the toes which form the feet; they become real fins, on the edges of which we however remark, in the *morses* and *lamantin*, rudiments or vestiges of nails indicating the five toes, which we indeed find, but concealed under the coriaceous skin that closely envelopes them.

In birds, the thoracic member is not intended to exercise the sense of touch; it therefore is not divided at the extremity into fingers or appendices, and is also almost entirely covered by long and close feathers. The feet are the only parts which possess the faculty of touch, and in them it is very much blunted by the horny laminæ or scales which cover the tarsi and the toes. Sometimes it is rendered still more obtuse by feathers, and always by the callosities in the form of excrescences and tumors which cover the feet inferiorly.

We have already described, in Vol. I, page 411, the number and direction of the toes in different birds. They are not in any species covered with hoofs, but are merely furnished with nails, which

which strengthen them, without injuring the sense of touch.

In the swimming or web-footed birds, as the *ducks*, the anterior toes are united by a membrane which extends to their extremity. Sometimes the pollex is also united to the other toes by this membrane. The birds however, in which this takes place, are of all the anseres those which employ their feet most frequently in touching and seizing substances. A short membrane unites merely the base of the anterior toes in gallinaceous birds. The two external toes are also united at their base in a number of the *Grallæ* and the rapacious birds.

The Passerine birds have in general the two external toes intimately united by their first phalanges; and in some genera, as the *king's-fishers*, and the *bee-eaters*, they are united nearly to the extremity.

The scaly membranes which border the toes in some wading birds, and their excessive length, as well as that of the nails in others, are also obstacles to touch.

From what we have stated, this sense appears to be very obtuse in birds; the scanfores, however, particularly the *parrots*, are, with the *owls*, those which possess it in the greatest perfection, and exercise it most frequently.

The number of the fingers, and their flexibility, vary more in reptiles than in all the other classes.

Common *lizards* have in general five fingers, of different lengths, well calculated to embrace objects in every direction. Some, as the *crocodiles*, have them palmated, at least in the posterior feet. Others, as the *gecko*, have them invested inferiorly with imbricated scales.

The *camelion* has them united by the skin, as far as the nails in two parts which form the forceps. The skin of their inferior surface is furnished with very sensible papillæ. The long lizards, called *seps* and *chalcides*, have only three very small toes. The *salamanders* and *frogs* have them naked, and destitute of nails; they therefore enjoy a very delicate touch. It ought to be still more exquisite in the *tree-frogs*, which have the extremity of the toes enlarged into a spongy disk, capable of adhering with force to bodies; but in the *tortoises*, which have the toes palmated, this sense must be less perfect. Lastly, the serpents are completely deprived of feet and toes.

This is also the case with fishes. Their fins are intended for motion only, and are of no use in ascertaining the forms of bodies.

What we have stated in Lecture Sixth, respecting the number and division of the feet in animals that have no vertebræ, appears to us sufficient to enable the reader to form an idea of the different degrees of perfection these parts possess as to the sense of touch.

ARTICLE VI.

Of the Appendices which supply the Place of the Fingers in exercising the Sense of Touch.

BESIDES the fingers, several animals have received different parts, which are sufficiently moveable and sensible to enable them to exercise the faculty of touch. In the species which want fingers, or which have them enveloped in insensible substances, these appendices supply their place.

The tails of several mammiferous animals, as the *sapajous*, the *opossums*, one species of *porcupine*, several species of *ant-eaters*, &c. are so organized, that they are capable of embracing bodies, and seizing them in the manner of a hand. In Lecture III. we have described the form of the bones, and the disposition of the muscles which are employed in this prehensile motion: the nerves are distributed to them in numerous ramifications; they arise from the termination of the medulla spinalis, and come out through the intercaudal foramina. Tails of this kind are usually destitute of hair on that part of their inferior surface which is applied to the bodies they seize.

We find similar tails in some reptiles, as the *camelion*, and the whole body of serpents, perform

form the same function, when they twist themselves round the objects they wish to feel or compress: this faculty is the more useful to them, as they are deprived of fingers, and every other appendix fitted to procure them the sensation of touch.

In the species of mammalia, which have a small number of fingers covered with horny hoofs on all the parts that support the weight of the body, the sense of touch seems to reside in the lips, which are the most moveable parts. We have an example of this in the Ruminantia and the Solipeda: we shall not here describe the muscles of these parts, as that may be done with more propriety in the Lecture on Mastication. The lips themselves have a very peculiar organization: the facial nerve, and that of the fifth pair, terminate in them by an infinite number of branches. These ramifications anastomose, and form various plexuses, which give to these parts a most exquisite sensibility. We know that they procure us the most delicious of all the sensations of touch.

In several animals, we find numerous and compact glands forming a layer below the skin, which is thin and covered with fine soft hairs; amongst them are placed some long stiff hairs, called *whiskers*, each of which is implanted into a papillated tubercle.

The whiskers, in consequence of their rigidity, easily communicate, to the nerves of the

lips, the slightest concussions they receive from surrounding bodies: on this account, though insensible themselves, they may be ranked among the appendices which assist the sense of touch.

The superior lip of the *rhinoceros* is prolonged into a small process, which that animal employs in feeling, grasping, tearing, &c. We are not acquainted with its muscles.

Hogs, moles, and shrews have a long pointed and moveable muzzle, to which the term *snout* is in particular applied, and which they also appear to employ as an organ of touch. In the substance of this part, there is frequently a peculiar bone, the form of which differs according to the species; it is situated between the intermaxillary and the nasal bones, and named the *bone of the snout*: the muscles of the snout shall be described when we treat of the sense of Smell, in order that we may give, in one view, every thing relative to the nose of animals.

The proboscis of the *elephant*, that of the *tapir*, which is less elongated, and the snout of the *musk shrew*, or *desman*, shall also be described in the same Lecture; but as they are employed by these animals in the manner of real hands, we notice them here as appendices of the organ of touch.

The crests, or fleshy parts on the heads of several birds, particularly in the Gallinaceous family, as *cocks, turkies, &c.* are perhaps also used as an organ of touch: these parts are destitute

titute of feathers ; they are soft and flaccid ; and the nerves they receive, though few in number, must convey to the animal the impressions of external bodies.

In animals which have no members with moveable fingers calculated to feel bodies, as fishes, the appendices are more numerous, larger, and more varied. Different names have been given to these prolongations of the skin : those which are placed about the mouth, or on the lip, are called *cirri* : those which proceed from the upper part, or sides of the head, are named *tentacula*. When they proceed from lateral parts of the body, they retain the name of *fingers*.

The *cirri* are usually soft ; they receive filaments from the fifth pair of nerves. There is only one in the *cod*, and other species of the genus *gadus* ; two in the *surmulets*, &c. ; four, which are very short, in the *carp* ; four in the *barbel* ; six or eight in the genus *cobitis*, and in several species of *silurus*, in which the *cirri* of the upper jaw are frequently very long. The *frog-fish*, the *gadus tau*, and others, have a great number round the lips.

The *tentacula* are organized like the *cirri*. In several species of the genus *lophius*, these appendices are susceptible of motion, and can be bent in different directions at the will of the animal. It is even pretended that they are used as a bait for catching small fish. In the species called *bislrrio*, the anterior tentacula divides like
a Y,

a Y, the branches of which terminate in a fleshy mass. The others are very long and conical. Several species of *Blennius* and *Scorpaena* have them above the eyes.

The lateral appendices of the body, which ichthyologists name fingers, have an osseous jointed stalk, which is similar to that of the radii of the pectoral fin, from which these fingers do not differ except in being free and moveable. They are chiefly remarked in the *trigla*, and in the *polynemus*.

There are still more varieties in the appendices of white-blooded animals.

We shall omit here the arms of the Cephalopoda, which we have already described among the organs of motion.

We shall also pass over the fleshy horns of the Gasteropoda, as we have described those of the snail in the Lecture on the Eye. Those of the other genera do not differ, except that they are incapable of that kind of motion by which they are retracted, and protruded like the finger of a glove. Their muscular fibres only become rigid or relaxed.

Several species have similar appendices around the cloak. Such are the *limpets*, the genus *balytis*, &c. Among the Acephala, the greater part are provided with these appendices, and some have them in great numbers. In the species which have the cloak completely open, they are placed around it, and particularly towards

wards the anus: this may be observed in *oysters*, *muscles*, *anodontites*, &c. In those in which the cloak opens by a tube only, the appendices are attached to the circumference of its orifice. Such are the genus *venus*, *cardium*, &c. The tube itself furnishes these animals with an excellent instrument of touch. The fleshy and ciliated arms of the genera *lingula* and *terebra-tula* are equally proper for this employment; but those of the *anatifæ* are very inferior, in consequence of their horny substance.

We also find cirri in several species of worms; they sometimes appear to be formed of different articulations, like the antennæ of insects. We have observed nerves proceeding into those of the *aphrodita* and *nereis*. There are none in the *lumbricus* and the *leech*, but they are supplied in the latter by the two disks which terminate their bodies.

The antennæ of insects appear to be principally employed in the sense of touch; we have described the nerves that proceed to them. Entomologists have described their forms, which are very numerous, and have even made them the foundation of characters for the genera. It would, therefore, be superfluous to describe them here.

Some larvæ have retractile tentacula, resembling those of snails.

In those of several species of *butterflies*, as the *podalirius*, *machaon*, and *apollo*, a single branch
is

is protruded between the occiput and the body, which is bifurcated at its extremity like the letter Y : this appendix appears rather an instrument of defence against the puncture of the *ichneumon*, than an organ of touch : it is moistened by a bitter and odorous liquor.

In the *fork-tailed bombyx* (*vinula*), the retractile appendices, resembling those of snails, are situated above the anus, at the extremity of two fleshy processes.

The arms, the tufts, and the flowers of several zoophytes ; the innumerable tentacula of the *sea stars*, *urchins*, and *actiniæ*, and the complicated branches of the *medusæ*, are also excellent organs of touch ; but these are sufficiently described by Naturalists.

ARTICLE VII.

Of the Insensible Parts which cover the Organs of Touch, and protect them against too strong Impressions.

THE epidermis defends the skin, and prevents the contact of external bodies from becoming painful ; but it would not, under all circumstances, be sufficient for this purpose. Nature has, therefore, armed it with various parts, composed

posed of the same materials as itself, but differing as to form and thickness, which serve to reinforce it; these are *hairs*, *feathers*, *scales*, *nails*, and *horns*.

1. *Of Hairs.*

Hairs are filaments of a horny substance, which are particularly intended to cover the skin of mammiferous animals; one of their extremities is implanted in the cutis, and is even frequently rooted in the *panniculus carnosus*; this extremity is enlarged into a bulb, more or less thick, which is inclosed in a membranous sheath, and which contains sometimes a small drop of blood. This cell is larger in proportion as the hair is young; if it be punctured at this time, the blood flows from it, and it becomes soft and flaccid.

All the part of each hair which is without the skin, is called the *shaft*; it is a very elongated cone, the free extremity of which forms the apex; the hairs grow from their base, and are therefore finer in young animals than in old: for the same reason, they seem to augment in number when cut, though, in fact, they increase only in diameter.

When the hairs rise out of the skin, they carry with them a small portion of the epidermis, which forms a kind of sheath at their base; this is gradually detached under the appearance of transparent and farinaceous scales.

Some

Some animals have, at their birth, the hair of some parts of their bodies more or less developed. In other parts no hair appears until a certain period of life.

As the hairs of the human body are very slender, it is difficult to examine their structure; but the bristles of *bogs*, and the whiskers of *cats*, and other *Sarcophaga*, may be very well employed in this kind of inquiry.

When we examine with the microscope the bristle of a *wild boar*, we observe that it is canalculated throughout the whole of its length, by about twenty furrows, formed by an equal number of filaments, the union of which constitutes the surface of the hair: in the middle of the bristle there are two canals, which contain an humour called the *medulla*. The filaments of the hair separate by desiccation, the separation commencing at the point, as may be observed in the bristles of brushes: the cavities are then empty, and we observe in them only some laminae which cross each other in different directions.

The hairs of the *elk*, the *musk*, the *hedge-hog*, the *tenrec*, *porcupine*, &c. are not altogether similar; their surface is covered with a horny lamina, the thickness of which varies, and on which we observe some furrows: internally they contain a white spongy substance, which appears at first sight similar to the pith of the elder tree (*sambucus*).

The colour of the hair seems partly to depend on that of the rete mucosum; for, as we have observed in animals which have the fur of different colours, the various spots seen upon the hair indicate others below them in the skin.

Even in the human species there are very striking relations of this kind. Negroes, in general, have the hair black. Persons who have red hair have almost always the skin freckled, or covered with reddish spots: those whose hairs are black have commonly a dark complexion.

The colour of the hairs exists in their horny substance, and not in their medulla, which is commonly white. This is particularly evident in the quills of the porcupine: the colours are infinitely various, and some hairs are coloured differently in several parts of their length: the works of Naturalists may be consulted on this subject.

The shape of the hairs is most frequently round, as those of the head, the mane, &c. They are flat on the tail of the *hippopotamus*, and on the body of the *great ant-eater*. They are, as it were, crimped in several species of the *Ruminantia*, and more particularly in the *must* (*moschus moschiferus*).

Their surface presents spiral channels in the *mules*. They are fine, long, and silky in some varieties of *goats*, *cats*, &c. They appear crisped and frizzled in the *rams*. They are stiff and elevated in the *bogs*, the *ledge bogs*, the *porcupines*,

spines, &c. From their great thickness in the two last animals, they have obtained the name of *spines*.

The climate has great influence on the nature of the hair, in domestic animals: in cold regions they become long and rigid, as we observe in the *Siberian dog*, the *Iceland ram*, &c. In the climate of Spain and Syria, they become tufted, fine and silky, as we find them in the *Spanish sheep*, in the *Maltese dogs*, and in the *goats*, *cats*, and *rabbits* of Angora. In very warm countries they become thin, or are altogether wanting, as in the *dogs of Guinea*, vulgarly called *Turkish dogs*, and in the *African and Indian sheep*.

Different names are given to all the varieties which the hairs present on different parts of the body. Hence the appellations—*hair*, *eye-lashes*, *whiskers*, *beard*, &c.

All mammiferous animals, the Cetacea excepted, have a certain quantity of hair. We shall briefly indicate its disposition in the different families.

Man has the whole body covered with scattered hairs, though, in some parts, they are so fine that they cannot easily be perceived: those of the head and the beard are the longest; those of the axillæ and the pubis are next in length; those of the interior of the nose and the ears, the eye-lashes, and the hair of the eye-brows, are still shorter; those of the other parts of the

body rank last in point of length ; there are more on the breast and on the belly, than on the back, which is contrary to the disposition in other animals. The palm of the hand and the sole of the foot never have any.

In *apes*, properly so called, the hair of the head is not, in general, longer than that on the other parts of the body : the hairs which cover the fore-arm point upwards to the elbow, instead of being directed towards the hand, as may be seen in the *orang outang*, and some other species. This is one of the circumstances in which these animals resemble man. In a great number of *Quadrumana* the buttocks are callous, and entirely destitute of hairs.

Among the *Cheiroptera*, which have the hair short, fine and villous, we observe that the *flying lemurs* have some on the lateral membrane of the tail, and on the ears. The *vespertilio lesurus* Lin. has also some on the membrane of the tail. The other species have only a few scattered hairs on the membranes of the wings, on the nose, and on the ears.

The *hedge-hogs* have the spines, of which we have spoken, placed only upon the back and the head : the members, and inferior surface of the body, are covered with stiff bristles. In this respect the *tenrecs* resemble the *hedge-hogs*. Some species have the bristles and the spines intermixed.

In *moles* and *shrews* the hair is so short, fine
and

and close, that their skin is as soft to the touch as velvet.

In the Carnivora the hair varies considerably. In the species which are covered with a fine fur, as the *weasels*, *sables*, *ermine*s, *martins*, &c. there are two kinds of hair; one close to the skin, which is very fine, thick-set, and intermixed; the other, which is longer and stiffer, and which alone appears on the surface; these are the two kinds of hair which constitute fine furs.

Nearly the same thing takes place in the fine haired Rodentia. In the *porcupines*, the spines on the head, neck and belly, are more slender, short and flexible, than those of the back: on the tail there are about a dozen, which resemble tubes of quills, truncated at their free extremity; they are fistular; their other extremity is rolled up, and is slender and very flexible; these tubes resound when the animal moves its skin; and it even appears that the urine can be conveyed into them in order to be thrown to a distance.

No family presents more variety with respect to the hairs than the Edentata.

In the *great ant-eater* (*myrmecophaga jubata*) the hair is broad and flat, and has a longitudinal furrow on both surfaces, so that each hair resembles a dried blade of grass. The *two-toed ant-eaters* are, on the contrary, covered with very fine wool: several have hard and cutting scales, placed one above the other like the tiles

of a roof, in the manner of the *pangolins* (*mains* Lin.); others are covered with prickles, as the *spinois ant-eater* (*echudna*). The *armadillo* genus (*dasypus*,) have, besides the scales or osseous bands which cover their back and head in regular compartments, some scattered hairs, which are short and rigid like those of the *elephant*: these hairs, however, fall off as the animal advances in age.

Of all the *Pachydermata*, the *bogs* have the greatest quantity of hairs, which, in them, are called *bristles*; they are scattered, and frequently bifid at their free extremity. There are very few in the other genera.

We have already noticed the nature of the hair of the *elk* and the *musk*. The *ox*, *stags*, *antelopes*, and *girafe* have, in general, short hair. *Camels* have it very fine and very soft, particularly the *camelus vicunna*; all have callosities, which are destitute of hairs on the knees and on the breast. The hair of *goats* is long and fine, and they have the chin furnished with a pointed beard. *Sheep* have the hair long, and distinguished by a crisped or frizzled appearance, and to it the term *wool* is applied.

Solipeda have the hair in general short, like the *Ruminantia*; that of the neck and tail, which is much the longest, is more particularly called *crines*.

The amphibious *mammalia* have short, rigid, and very close hair.

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We have already observed that the Cetacea have no hair.

The chemical analysis of the hair of all these animals, whatever form it assumes, whether that of *wool, bristles, spines, quills, scales, &c.* affords nearly the same results: when subjected to the action of fire, and in open vessels, it fuses or liquifies at first by swelling up; it afterwards emits a white flame, and resolves into a black carbon, the incineration of which is very difficult.

Hair, on distillation, yields a reddish liquor, which contains prussiat of ammoniac, and another salt of an ammoniacal basis, combined with a particular animal acid, which Berthollet has named zoonate of ammoniac: the charcoal, which remains at the bottom of the still, is light: it contains carbon and the phosphat of lime.

The hair does not completely dissolve in boiling water, but there is separated from it a mucilaginous matter, which is its medulla; it is completely soluble in caustic alkalis, and in some acids.

2. Of Feathers.

Feathers are proper to birds, as hairs are to mammalia, and scales to reptiles and fishes.

Before we describe the forms and numerous varieties which feathers present, it is right to notice their structure. To give a distinct idea

of this part of the subject, we shall point out the manner in which they grow.

At the time the young bird leaves the egg, and for some days after, it is covered more or less with hairs, except on the region of the belly. These hairs, which vary in colour and thickness, come out of the skin in fasciculi, each composed of ten or twelve hairs; they are implanted in a bulb or follicle, which appears to contain the rudiment or sheath of the feather: after a few days the feather appears externally, in the form of a blackish tube; we then observe that the common fasciculus of the hairs is attached to the end of this tube, and that it even penetrates into the interior of the sheath.

In proportion as the feather grows, and is developed, the hair falls off. In some families, as the birds of prey, it adheres for a long time to the extremity of the feather, in the form of a kind of down.

It is only at this period that we observe hairs on the bodies of birds; for when the feathers are renewed in the moulting season, there is then no appearance of them.

We have already observed, that the sheath of the feather becomes apparent some days after the bird is hatched: the quills, or great feathers of the wings and the tail, appear first; the down manifests itself next, and lastly, the small feathers of the body.

The sheath is a tube, closed on all parts, except

cept at the extremity, which is fixed in the skin; we observe there a small hole, or umbilicus, by which the blood vessels pass into the cavity of the tube; when the feather is plucked out, therefore, a slight hemorrhage takes place.

On leaving the skin, the sheath splits, in consequence of being dried in the air, and the expansive force of the contained parts. A longitudinal laceration takes place, and the extremity of the *shaft* of the feather comes out: in proportion as the shaft grows, the sheath becomes more torn, and its desiccated tunics are detached in the form of thin pellucid scales.

If about this period the tube be opened longitudinally, it will be found that it is formed of numerous and cylindrical strata of a horny and transparent substance, and that it contains a cylinder of gelatinous matter, into which the blood-vessels penetrate.

The external extremity of this gelatinous cylinder is conical, and harder than the other parts; it is covered by a layer of black matter, which is the first rudiment of the barbs of the feather.

The growth of this gelatinous cylinder takes place longitudinally; the conical part, which forms its apex, comes out of the sheath, and brings with it the stratum of black matter, which splits in drying, and forms the first barbs. The shaft of the feather elongates and hardens; the first cone has scarcely made its exit from the
sheath

sheath when a second is formed, which comes out in its turn, developing new barbs, and making an addition to the length of the shaft, which grows always at its base: at last the shaft, with the whole of its vane, is protruded from the sheath, which becomes desiccated internally: we then observe only membranous cones inserted into each other, similar to those which, by their development, protrude the barbs externally, and which form what is called the heart of the feather.

When the growth of the feather is completed, the tubular portion becomes solid, and is continued with the shaft, the germ of which it formerly contained; it is a cylinder which joins force and elasticity to specific levity. The dry and vesicular matter we observe within it, is the residuum, or vestige of the large fleshy canal which existed in a less advanced age; it is a sort of cavernous body, formed of several small cups or cells succeeding each other; these cells are more elongated, in proportion as they approach the shaft; they then become similar to small tunnels, which are of different lengths according to the species, and are incased into each other. The last of the cells is divided into two; one passes without the line in the longitudinal furrow which appears at that part; the other penetrates even into the interior of the shaft.

The shaft of the feather is the continuation of
the

the tube. It is a cone more or less elongated, convex on one surface, and flat and furrowed on the other. The barbs are attached to its sides. All the superficies of the shaft is covered by horny matter, which seems to proceed from the tube. Internally, it is filled up by a white and very light spongy substance, similar to that which we find in the quills of the porcupine.

The barbs are small laminæ of a horny nature, planted into the sides of the shaft. They are applied to each other throughout their whole length, like the leaves of a book. Sometimes they are applied very closely, as in the feathers of the *goose*, or the *swan*; sometimes in a more loose manner, as in the rump feathers of the *peacock*.

The beards are themselves shafts, from the edges of which an infinite number of hairs proceed. These hairs are sometimes loose, and detached from each other; sometimes compound and sub-divided, but most frequently so fine and so compact that they can only be perceived with a magnifying glass. By means of these hairs or *barbulæ*, the barbs of the feather are so intimately attached to each other as to prevent the passage of the air.

Such is the general organization of the feathers. We shall now consider the varieties which they present.

All birds change their feathers, at least once a year. The old feather is pushed off by a new

one, which obstructs the vessels destined to the nourishment of the former. All the feathers do not fall off at once. The moulting in general takes place about the period of laying.

Different names are given to the feathers, according to the regions which they occupy. They are disposed in quincunces on the body. There are never any on the lateral lines of the neck and of the breast, nor on the umbilical region. The term *quills* has been given to the feathers of the wings and tail. Those which are implanted in the humerus have been called *secondary*. Their number varies considerably; but there are constantly ten attached to the metacarpus, and the fingers, which are called *primary quills*.

We shall state some examples of the principal varieties of the feathers, independent of their colours, which are so brilliant and so numerous that we could not find language to describe them.

All the feathers of the *cassawary* may be called *barblefs*. The wing quills of that bird are only five in number, and resemble the prickles of the porcupine. The other feathers of the body have two shafts from one tube, and their barbs are detached, long, and destitute of barbules. They resemble *crines*.

The feathers that form the crest of the *peacock* have no barbules in their middle and inferior part. Those which form the crest of the
balcaric

balearic crane (*ardea pavonina*,) are twisted spirally on themselves, and their barbs are only fine hairs. The crest of the *little egret* (*ardea garzetta*,) is also composed of similar feathers. In the *male turkey* there is a tuft of hairs at the base of the neck, which may be regarded as barblefs feathers, &c.

We shall give the name of *loose feathers* to those which, though they have the barbules very conspicuous, and frequently very long, are so far separate that they cannot be attached to each other. Such are the *hypochondriac* feathers of the *bird of paradise*, those of the rump of the *peacock*, of the thighs of the *jabiru*, and the *balearic crane*; those of the body in *toucans*, and those which surround the ears in *owls*, &c.

The term *floating feathers* may be very well applied to those of which the barbs, though provided with barbules, are set wide, and are flexible, as in the feathers of the tail of the *ostrich*.

The nocturnal birds of prey have soft feathers, the barbs of which are covered with a long and silky down. On this account we scarcely hear the flapping of their wings when they fly. Feathers of this kind may be called *downy*.

Other birds have the feathers of the body furnished with barbs, which are so fine and glossy that we may term them *silken*. Such are those of the *bullfinch*, of the *purple-breasted flycatcher* (*muscicapa rubricollis*,) of the *tanagra septicolor*; those

those of the head of the *red-headed manakin*, and of the *momot* (*rampastos momota*).

We shall name those *satın feathers* which have close-set barbs, bearing long, fine, and silky barbules, disposed on the surface in such a manner as to imitate *satın*. Such are the rump feathers of the *golden thrush*, those of the tail of the *jay*, and those of the neck of the *common duck*.

We shall apply the term *metallic* to the feathers which have barbs of brilliant colours, resembling the lustre of polished metals. We have examples of this kind in the feathers of the *humming-bird*, of the *jacamar*, of the *curucui*, of the *peacock*, of the *paradisea aurea*, &c. This brilliancy is occasioned by the breadth of the barbs, and the smooth surface they present to the eye.

We shall designate by the word *gemmaceous*, all the little feathers which have the barbs that terminate the shaft, coloured by imbricated semicircles like the scales of a fish. Of this kind are the head and throat feathers of the *ruby-necked humming-bird* (*trochilus moschitus*), and those of the head and belly of the *amethystine humming-bird*. They exceed in lustre the preceding kind of feathers, and resemble precious stones. The effect is produced by the extreme density of their barbs, and the polish of their surfaces.

Lastly, we shall make but one order of the *common feathers*, such as belong to *cocks*, *pigeons*, *rollers*, *ravens*, &c.

All birds have feathers on some parts of their body. Several species have them even upon their toes, as *owls*, and some varieties of *cocks* and *pigeons*. Others are deprived of them in certain parts of the body, as *vultures* and *turkies* on the head, the *ostrich* and the wading birds on the thighs. Some even want them on the wings, as the *manchots*.

Chemical experiments on the composition of the feathers, prove that they have a very great analogy to hair: The same results are obtained from both by the same processes. Feathers however contain less mucilaginous matter.

3. Of Horns.

There are prolongations of horny substance which grow upon the head of certain species of mammalia, especially the Ruminantia. They also appear on several other parts of animals.

We have already described the development of the antlers or deciduous horns, in Lect. II. Art. 2, when we treated of Osteogeny. We shall now notice the horns which are formed upon processes of bone, and which grow at their root or base, and have a great resemblance to the integuments.

In the third month of conception, while the fœtus of the cow is still enclosed in the membrane, the cartilaginous os frontis presents no mark of the horns which it is afterwards to bear.

Towards

Towards the seventh month, it is in part ossified, and presents in its two portions the small tubercle which appears to be produced by the elevation of the osseous lamina. These bony tumours soon after appear externally. They raise the skin, which becomes callous at that part, in proportion as the tumour grows. It becomes at last horny as it elongates, and it forms a kind of sheath which covers externally the process of the frontal bone. Between this sheath there are numerous branches of blood vessels which serve to nourish the osseous part.

The horns therefore are only solid, hard, elastic, and insensible sheaths, which protect the osseous prolongation of the frontal bone. These sheaths are generally of a conical figure, and broadest at the base, the extremity from which they grow. Their curvatures vary with the species, and have been described by naturalists. They also present different channels or transverse furrows, which depend on the age of the animal, and which denote the number of years it has lived in a very certain manner according to the species.

The texture of the horns appears to be much the same in the *goat*, *sheep*, *antelope*, and *ox*. They consist of fibres of a substance analogous to hair, which appear agglutinated in a very solid manner. In the two first genera these fibres are short, and covered by superincumbent layers
like

like tiles. In the two last they are longer, more compact, and form elongated horns incased in each other.

The horns of the *Rhinoceros* appear to differ somewhat from those of the Ruminantia. They have no osseous part, and are not situated on the os frontis, but on the lines of the nose. They are formed however of the same substance, and we even observe more distinctly in the horn of this animal the fibres analogous to hairs. The base of the horn, indeed, presents externally an infinite number of rigid hairs, which seem to separate from the mass, and which render that part rough to the touch, like a brush. When sawed transversely, and examined with a glass, we perceive a multitude of pores that seem to indicate the intervals resulting from the union of the agglutinated hairs. When divided length-ways, numerous longitudinal and parallel furrows also demonstrate the same structure. This kind of horn is attached by the skin only. Those of the *Rhinoceros bicornis* appear always in a degree moveable. When fixed, as in the *unicornis*, there is a thick mucus interposed between its base and the bone on which it is situated.

The colour of the horns depends, like that of the hairs, on the mucous substance. Their chemical analysis affords similar results. Heat softens, and even fuses them. It is the agent

employed in manufacturing them into different articles.

From this examination of the horns, it appears that they differ essentially from the osseous prolongations called *antlers* of deer. The latter increase at the extremity. They are covered with skin during their growth. They fall off, and are reproduced at a certain period of the year. The others grow at the base, are not covered by the skin, and are permanent.

We find several other horny parts in animals. Such are the protuberances of the head in *horn-bills*, the *guinea-fowl*, the *Cassowary*, &c. These are laminæ of horny substance which invest the osseous sinuses, of which we have already spoken, and which we shall describe hereafter, in treating of the organs to which they belong. In the same manner we shall postpone our account of the horn which covers the jaws of birds and several reptiles, the spines of the wings, and the spurs. The external description of these parts is indeed more the province of the natural historian, than of the anatomist.

4. Of Nails.

This name is given to the horny prolongations which arm and protect the extremities of the fingers or toes in mammalia, birds, and reptiles. Their number is in general equal to that of the fingers and toes. Their form, as we have
already

already observed in the article on the division of the extremities, appears to depend on that of the last phalanx. They are to these phalanges what the hollow horns are to the processes of the os frontis which they cover.

The nails seem incased in a duplicature of the skin. The part covered by the skin is called the *root*. They grow by that part precisely in the manner of hairs, but the opposite extremity wears by the friction of the ground, and by other uses to which animals apply their nails. We observe, therefore, that they grow exceedingly long in animals that are confined, and have few opportunities of motion.

No part of the nail is sensible, except that which adheres to the skin. The free extremity may be cut, or broken, without occasioning any pain.

The colour depends upon that of the rete mucosum, as we have already remarked.

The human nails appear in the third month of conception; the development takes place nearly in the same manner as in the common horns, which we have already described. At first they appear like a kind of cartilage, which gradually acquires a proper consistency. Almost all animals have at their birth the nails in some degree formed.

The nails of man, and the greater part of ungulated animals, appear to be formed of extremely thin strata placed one upon another. The

anterior laminae are larger than those of the inferior surface; therefore we do not perceive externally the kind of imbrication which takes place: but in diseases, or upon a transverse section of the nail, after it has been completely dried, this structure becomes manifest. Frequently we observe on the superficies of the nail, some striae, or very fine longitudinal and parallel lines, which appear to result from the manner in which this part is moulded upon the laminae it covers.

The nails seem intended to protect the extremities of the fingers and toes. They are, in general, wanting in those animals which do not employ these parts either in walking or grasping. We have examples of this circumstance in *bats*, in the wings of birds, with the exception of some species of the *palamedea*, *tringa*, *charadrius*, and *parra*; in the fins of several *tortoises*; and in the claws of some other aquatic reptiles, as *frogs*, *salamanders*, &c.; lastly, in the members or fins of fishes.

Birds have commonly nails on the toes only. They are strong, and resemble those of the *Sarcophaga* and birds of prey. They are flat in the web-footed, slender pointed, and very much elongated on the posterior toe of *larks* and *jacanas* (*parra* Lin.)

The nail is serrated on one of its sides in the middle toe of the *goat-suckers* (*caprimulgus* Lin.) and of the *herons*.

There

There is a supernumerary nail, or osseous process, which forms a kind of horn on the tarsus of the greater number of gallinæ. It is called the *spur*. The *Iris peacock* (*Pavo bicalcaratus*) has two. They become very long in the *cock*. A curious experiment has been performed when pullets are made capons, by cutting off this spur, and fixing it in the place of the comb. It takes root there, and grows to a considerable size.

The nails present no particularity in reptiles.

The chemical analysis of the nails affords nearly the same result as that of the hairs and feathers, parts with which they have much relation, both in their mode of growth, and in their structure.

Hoofs differ from nails in the following circumstances. They envelope the phalanx inferiorly as well as superiorly. They are neither pointed nor cutting at the extremity, and both surfaces meet to form a round and blunt edge.

Their interior is rendered remarkable by deep and regular furrows, which receive projecting laminæ, and which are not observable in nails. These furrows are particularly remarkable in the *elephant* and *rhinoceros*. They are also very strongly marked in the *horse*, but less conspicuous in the Ruminantia.

Between the nails and the soft parts of the phalanx, there is always a layer of mucous matter; and in the inferior part of the hoof, there is a

soft substance abounding in nerves, which give a degree of sensibility to that part.

5. *Of Scales.*

These are laminæ, or small plates, of a substance which is either horny or osseous, and which cover certain parts of the body of vertebral animals.

Scales have a great resemblance to hairs, feathers, horns, and nails, in the manner of their development, in their use, and in their chemical analysis.

They might generally be considered as very flat horns, as hairs are very slender horns.

Almost all reptiles, and the greater number of fishes, are entirely covered with scales: we observe them only on some parts of the body in a very few species of mammalia; and in birds, they are most commonly found on the feet alone.

The term *scales* is here applied to very different substances; it being usual to include, under this denomination, all the parts we are about to describe in a general manner, in the four classes of red-blooded animals.

The scales of the *pangolin*, and *long-tailed manis*, are a kind of flat nails, of a horny substance; they are thick; their anterior third, which is bevelled and sharp-edged, is free, but they adhere to the skin by their other portion. Their external surface is channelled longitudinally,

nally, particularly in the *long-tailed manis*, in which they usually terminate in three points; they are furrowed transversely on the side next the skin, and appear to be formed of imbricated laminæ.

In the *armadillos*, the scales are small compartments of a calcareous substance, covered with thick, smooth, varnish-like epidermis.

The scales which cover the tail of the *beaver*, are similar to those of the feet of birds.

Those on the tails of *rats* and *opossums*, and several other prehensile tailed animals, are of the same kind.

The scales of the feet of birds consist of thin laminæ, of a horny substance.

The scales which cover the wings of *manchots*, are only very short feathers, the barbs of which are united to the epidermis.

Among the reptiles the scales vary greatly, according to the genera. In *tortoises* they are plates of a horny substance, which are very hard and dense in the greater number. But in the *testudo coriacea*, and several others, they are soft and flexible: sometimes these scales are imbricated, as in the *hawkes-bill turtle*; and then they are smooth, or channelled longitudinally: at other times they form compartments of different figures; in the latter case they are more or less convex, and surrounded with furrows, or concentric channels, in the midst of which

are points, which are either scabrous, elevated, or blunt, as in the species named *geometrica*, *græca*, &c.

In the *crocodile* the scales are osseous, and disposed in bands, as in the *armadillos*; they are imbricated like those of fishes, and are marked by a longitudinal ridge, or elevated line.

In the greater number of *lizards* and *serpents*, the scales are only small plates, or compartments of the skin, between which the epidermis is continued and moulded. The *skinks* and *slow-worm* have real scales, which lie upon each other like tiles, in the manner of the scales of fishes.

In the class of fishes, all the solid parts with which the body is covered are called scales; but the structure and use of these insensible parts render it necessary that we should consider them more in detail.

We name *scales* those thin horny plates which are imbricated like ancient coats of mail, and usually crescent-shaped at their unconnected edge, as in *carp*, *pike*, &c. These plates most commonly present longitudinal lines, which are rough to the touch: their external third is coloured by the rete mucosum. Those above the lateral line have usually a furrow on the surface next the body; sometimes they are perforated by an oblique hole, through which a membranous canal passes; these scales are covered with scabrous points in the *balistes*. They are finely serrated on their edges in the *sole* (*pleuronectes solea*),

solea). They are very small in *eels*, in which we cannot perceive them until the skin is dried. But they grow to the length of seven centimeters in the *great scaled bream*; in this fish, in particular, the structure of the scales may be easily observed. Besides the longitudinal, or rather radiated lines of which we have spoken, we perceive concentric striæ, which seem to indicate that the scales grow in every direction, by the addition of new layers in the manner of horns and nails.

We may name the plates of calcareous matter which are contained in the skin, *osseous escutcheons*. In the *trunk-fish* (*ostracion*), &c. they are small compartments of a regular figure, and disposed like mosaic work. In the *sturgeon*, these plates are of different forms, hollowed externally by numerous holes, and bear a longitudinal ridge. In the *turbot* (*pleuronectes maximus*), the scutcheons are small, and in the form of lozenges. In the *effox osseus* the plates are rhomboidal, and covered with a compact and glossy epidermis.

In the *thornback* the spines are curvated points, of a transparent osseous substance; the base of the spine is white, opaque, and hollow internally; it exhibits the print of the muscular fibres, into which it is implanted.

These spines are nearly similar in several species of *diodon*, and other genera; but they have not a round and hollow base, as in the *ray*.

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In the *piked dog-fish* (*Squalus acanthias* Lin.) the scales or prolongations which supply their place are small bristly laminæ; they are flat, bent, figured like myrtle-leaves, and have a longitudinal ridge in their middle.

In other species of the same genus, as the great *dog-fish*; in the genus *theutis*, the *remora*, &c. the skin is covered with small tubercles, which are extremely hard, very close, rough to the touch, and which cannot properly be called scales.

The scales are covered in fishes, as well as in all the other classes, by the epidermis, which varies in thickness and softness according to the species. It is the epidermis only which is cast by *serpents*: the scales below it continue to adhere to the skin; it appears that the hairs, horns and nails are also formed under the epidermis, which is always found on these parts, unless it has been desiccated, and worn off by friction.

All the insensible parts are destitute of nerves and vessels, except when they include cavities that contain them, as is the case with feathers, the spines of the *ray*, &c.

They grow like the epidermis, by the addition of new layers, which transude from the skin, and become united to the laminæ that have been already formed.

6. *Of the Insensible Parts in the Animals without Vertebrae.*

Little remains to be said on these parts, since the skin of the greater number of invertebral animals is hard and insensible, as has been already described.

In Lecture II. Article 2. we have explained the manner in which the shell is developed. We have also, in the Article on the Skin, in the present Lecture, made some observations on the colour of the calcareous shell of the Mollusca and the Crustacea.

The horny substance which serves both for bone and skin to the greater number of perfect insects, has also been described.

The hairs or spines appear to be a continuation of the epidermis, for they are cast off with it in moulting; and others are reproduced, which are longer than the preceding.

The scales of the wings and of the body in the Lepidoptera, and some other orders of insects, are small horny plates, differently coloured, implanted in the skin, and covering it like tiles upon a house.

The plumes of the *pterophorus*, of some butterflies, and of the tailed *hesperia*, are only prolongations or shreds of the wings furnished with long hairs on the sides.

A number of animals of the class *vermes* have the body furnished with bundles of hairs, which
are

are sometimes stiff and retractile, and serve for feet, as we have pointed out in the genera *nereis*, *terebilla*, *lumbricus*, &c. In the *aphrodita* there are, besides these bristles employed in progression, an infinite number of other hairs, which are long, flexible, and of a changeable sea-green colour; there is also a tomentous felt-like substance covering the branchiæ, through which the water is strained.

We refer to Lecture VI. Article 8. for the insensible parts of Zoophytes.

LECTURE FIFTEENTH.

OF THE ORGANS OF SMELL AND TASTE.

TASTE and SMELL have a more immediate relation to Touch, than Seeing and Hearing; they seem indeed only more exalted modifications of the sense of Feeling, by which we are enabled to perceive the differences of the more minute particles of bodies when they are dissolved in liquids, or in the atmosphere; their organs are essentially the same as that employed in ordinary touch, and differ from it only by a greater development of the nerves, and a finer and softer texture in the other parts. The organs of which we have to treat are, indeed, real prolongations of the skin, formed of all its different layers: we therefore find the epidermis, the rete mucosum, the villous surface, the true skin, and the cellular substance. The tongue of certain animals is even furnished with insensible teguments, as scales, spines, teeth, &c.

We shall now describe the Organs of Smell and Taste, in the manner we have examined the other senses; that is, both as to their essential parts, and with respect to those that serve only to augment or diminish the force and extent of the sensations.

SEC.

SECTION FIRST.

OF THE ORGANS OF SMELL.

ARTICLE I.

Of the Sense, and its Organs in general.

OF all the substances which act on our senses, those which produce the sensation of Smell are least understood, though their impressions on the animal body are, perhaps, of the most powerful and extensive kind.

We know, in general, that this sensation is caused by volatile particles dissolved or floating in the atmosphere, and conveyed by the air into the nose, where they are diffused.

Some bodies are always odorous, because, the whole or a part of their substance being volatile, it constantly exhales. Others become odorous under certain circumstances: for example, when a volatile principle, which has been retained by its affinity with other substances, is extricated by the addition of some new body; as the salts which contain *ammoniac*, after a more powerful alkali has disengaged it: or when there

is united to them an external body, capable of forming a volatile composition, as *muriatic acid* is changed into *oxygenated muriatic acid*, by the accession of new oxygen: or, lastly, when a substance, which deprived the body into which it had entered, of its volatility, is dislodged; as *nitric acid*, when it is changed into *nitrous*, by the loss of a part of its oxygen. It is, doubtless, in one or other of these ways that the presence or absence of heat, light, or humidity, may render certain bodies odorous: thus some flowers possess that quality only during the night, clay acquires it when it is moistened, &c.

Odours appear, therefore, to be propagated in the air, in the same manner as one fluid diffuses itself, and mixes with another: their motion is not direct like that of light; it is not rapid, and is neither susceptible of refraction nor reflection; it resembles that of the matter of heat, with this difference only, that the substances through which the air cannot pass, are also impermeable to odours.

Odours may combine with different bodies by affinity, and are frequently destroyed by the same means; they also adhere in preference to certain bodies, according to the nature of each. Some are most easily retained in spirits, others in oils, &c.

These phænomena, it will be perceived, seem to prove that each smell is occasioned by a particular substance floating in the atmosphere.

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There are others, however, which appear to indicate that odour is not always produced in this manner.

Several bodies yield a strong smell for a great length of time, without sustaining any sensible loss of substance. Such, for example, is musk. Some odours are experienced when no evaporation can be observed, as the smell which arises from the friction of copper, that produced by the fusion of a great number of bodies, and even by the melting of common ice. In other cases, real evaporations produce no sensible odour; this may be remarked on the disengagement of several gases, and even on the ordinary evaporation of water. Perhaps these phænomena only prove that the force of the sensation is not proportional to the quantity of the substance by which it is excited, but that it depends on the nature and degree of the affinity of that substance with the nervous fluid. The action of the greater part of odorous substances on the nervous system, is rendered manifest by a number of other effects besides the sensation of smell; some produce faintings, others giddiness, or even convulsions. Some, on the contrary, serve to remove these disorders: indeed the greater part of medicaments act in general rather by their volatile and odorous parts, than by their other principles; and afford new proofs of the influence exercised in the animal economy by the gaseous and impalpable substances,

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the greater part of which are doubtless still unknown to us.

We know not whether odours have a peculiar vehicle, besides the matter of heat which is common to them all in their quality of vapours or elastic fluids.

We are ignorant of the circumstances which render them agreeable or disagreeable to us; and we can as little explain why smells, which are disgusting to us, seem to be pleasing to certain animals, which testify also an indifference for those that are delicious to man. Though the human species, and other animals, are in general fond of the odour of those substances which serve for their particular food, that odour is displeasing when they are fed: on the contrary, they sometimes are fond, to a degree of madness, of the odour of substances which are of no use to them, as *cats* are of *nepeta*, &c. Odours that are constantly disagreeable, proceed in general from substances which may prove injurious. Venomous plants, corrupt flesh, and poisonous metals, have almost always a disagreeable smell.

Whatever may be the answers given to these questions, the organ of Smell, in all the animals in which it has been observed to exist, is a very fine expansion of the skin, abounding in vessels and nerves moistened by a quantity of mucous matter, and acted on by air or water impregnated with odorous substances; for it appears,

that a fish smells in water in the same manner as other animals in air: thus odorous substances, thrown into water to serve as bait, attract fishes from a very considerable distance, in the same manner as they would attract quadrupeds or birds through the medium of the atmosphere. We know not whether substances, which are insoluble, indiffusible, and inodorous in the air, but which dissolve in water, as for example salt, act in the latter medium on the organ of smell of fishes.

In all the red-blooded animals, which respire by lungs, the organs of smell are so situated, in the passage of the air, as to be impressed by it at the moment of inspiration. In fishes, they are simply at the end of the muzzle, and must receive impressions from the water when the fish swims forward.

We are not sufficiently acquainted with the nature of the olfactory membrane, nor with that of the nerves distributed to it, to enable us to form an opinion respecting the degree and the kind of sensations they procure to different animals. It may, however, be at first sight presumed, that, all things in other respects being equal, the animals in which the olfactory membrane is most extensive, enjoy the sensation of smell most exquisitely, and experience confirms this conjecture. It would be curious to learn, why the animals which possess the sense of smell in the highest degree, are precisely those which
feed

feed on the most fetid substances, as we observe in *dogs* which eat carrion. Perhaps the *Sarcophaga* have, of all animals, the finest smell, as it is necessary they should be able to trace their prey from a great distance.

In treating of the organs of Smell, we shall have to examine the structure and extent of the pituitary or olfactory membrane, the size and number of the nerves distributed to it, and the means by which it receives the odorous exhalations. These shall form the subjects of the following articles.

ARTICLE II.

Of the Form and Magnitude of the Nasal Cavity.

THIS subject is included in several of the Articles of Lecture VIII: we shall therefore content ourselves by referring—

For the composition of the nasal fossæ, to pages 60, &c. of this volume.

The external aperture, pages 82, &c.

Their size and their vertical section, pages 10, c.

Their transverse section, and their direction, pages 82, &c.

We shall merely add here, that, in some fishes, the nasal fossæ are not formed in the muzzle, but, on the contrary, sustained upon pedicles, and elevated like drinking-glasses. Of this number is the *frog-fish*.

ARTICLE III.

Of the Sinuses which increase the Extent of the Nasal Cavity.

IT is not proved that the sense of Smell resides in these sinuses: the membrane which covers them is thinner than that of the rest of the nose; and it does not appear to receive any ramifications of the olfactory nerve; no use is attributed to them, except that of secreting an aqueous humour calculated for lubricating the interior of the nose. It is certain, however, that the animals which have the most perfect smell, have these sinuses the longest; perhaps they are intended as reservoirs for a great quantity of air impregnated with odorous particles, in order that it may act more forcibly on the olfactory membrane.

These sinuses hardly exist in young animals, and are not fully developed until puberty.

They are found only in man and quadrupeds; they

they communicate with the cavity of the nose by contracted apertures.

There are three sinuses, which are named, from the parts they occupy, the *frontal*, the *sphenoidal*, and the *maxillary*.

A. In Man.

The *frontal sinuses* open into the upper part of the vault of the nose; they extend about an inch in height, and a little more in breadth on each side above the eye-brows; they are separated from each other by a vertical septum.

The *sphenoidal sinuses* open into the posterior and inferior part of the nasal vault; they occupy all the interior of the os sphenoides, under the anterior and middle part of the sella turcica; they are also separated by a vertical septum.

The *maxillary sinuses*, or *antra Highmorianae*, fill the whole body of the superior maxillary bones; they open into the sides of the nasal cavity, near its bottom.

B. In other Mammiferous Animals.

1. The Frontal Sinuses.

These are very small in *monkeys*. They are even entirely wanting in the greater number of *paggots* and *guenons*. But they are considerably extensive in some of the *sapajous*.

Among the *Sarcophaga*, *dogs*, *wolves*, *foxes*,

&c. have them most considerable; they occupy the whole extent of the os frontis, fill the interior of the two post-orbital processes, and descend on each side in the posterior wall of the orbit. They are somewhat less extensive in the *bear* towards the sides, and in the *cat* posteriorly. The sinuses of the *coati* resemble those of the *cat*. Those of the *civet* occupy only the posterior part of the frontal bone. There are none in the *badger*, in *bats*, nor in the greater number of *weasels*. The excavations of the post-orbital processes, it is true, exist in those animals, but they are only prolongations of the nasal cavity, communicating freely with it, and not by a narrow aperture.

With respect to the Rodentia, these sinuses are wanting in *rats*, the *marmot*, the *agouti*, the *squirrel*, the *beaver*, and the *hare*. But they are very large in the *porcupine*, and penetrate even into the substance of the nasal bones.

The same difference occurs among the Edentata. The *ant-eater* and the *pangolin* have no frontal sinuses. The *armadillo* has them of a moderate size. But in the *slotb* they are very large, and in the adult animal extend nearly to the occiput.

The Ruminantia exhibit varieties equally striking. The *stag* appears to have no frontal sinuses. The *ox*, the *goat*, and the *sheep*, have them of an enormous size, and extending into the substance of the osseous processes which fill the

the horns. Those of *antelopes* occupy the thickness of the os frontis, but the osseous part of the horns is solid. The *camel* has, also numerous sinuses, which are very much divided, but they do not extend further back than the frontal bone.

Of all animals, the *elephant* has the largest frontal sinuses. It is their magnitude which gives to his cranium the extraordinary thickness which distinguishes it from all others. They extend through the whole substance of the parietal and temporal bones, and even the articular condyles of the os occipitis. Numerous and singular laminæ divide them into cells, all of which communicate with each other.

The frontal sinuses of *hogs* are equally extensive, though less elevated. They proceed to the occiput, and are only separated from each other by some osseous laminæ, which are placed in a longitudinal or slightly oblique direction, and which do not entirely intercept communication. There are four rows in the *babiroussa*, and seven or eight in the *common hog*. The *hipopotamus*, and the *rhinoceros*, want the frontal sinuses.

The frontal sinuses of the *horse* occupy a great part of the os frontis. They do not open immediately into the nose, but communicate, by a very large aperture on each side, with the posterior maxillary sinus; for this animal has two.

2. *The Maxillary Sinuses.*

The relations of these sinuses do not correspond to those we have pointed out in the frontal. They are rather proportionally smaller in the *Quadrumana* than in man. They are reduced almost to nothing in the *Sarcophaga*, the greater part of the *Rodentia* and *Edentata*, and, in general, in all animals in which the maxillary bone does not form a floor under the orbits. These sinuses exist however, and are even very considerable in the *porcupine*; but in the greater part of the other unguiculated mammalia, even when the maxillary bone is hollow, the cavity forms a part of that of the nose, and cannot be called a sinus, as it has no contracted aperture.

Hogs have no sinus that can properly be called maxillary, but they have one in the base of the *os malæ*, which is particularly extensive in the *Ethiopian hog*. The *hippopotamus* has a small one in the same place.

The maxillary sinuses of the *Ruminantia* are very large, and open into the nose by a narrow fissure behind the inferior spongy bones.

The *horse* has two, the posterior is the largest. It opens laterally towards the back and upper part of the nose by a triangular hole. Its parietes form a large projection within the nose, which separates the portion of the nares, occupied by the ethmoidal foramina, from that in
which

which the two great turbinated bones are situated. The anterior maxillary sinus opens into the bottom of this last part.

The interior of the ossa maxillaria of the *elephant* is, like that of the bones of his skull, divided into a multitude of very large cells, all of which communicate together, and one opens by a hole into the side of the nose.

3. *The Sphenoidal Sinuses.*

These sinuses are small in proportion as the sella turcica is flat.

Monkeys and *makis* have them smaller than man. The *Sarcophaga* have them also smaller, and of a more elongated form. The *otter*, the *seal*, and the *pole-cat*, want them entirely. It also appears, that there are none in the other unguiculated Mammalia, nor in the Ruminantia. The *hog* and the *hippopotamus* have them, but they are very small. In the *elephant* they are enormous, and occupy even a part of the pterygoid processes. They are not divided into small cells, like the other sinuses of that animal.

In the *horse*, each opens into the posterior maxillary sinus of the same side.

I have not found sinuses of any kind in the bones of the Cetacea.

The cavities of the bones of the cranium in birds, communicate with their ears, and not with their nose. The large vacuities in the
beaks

beaks of the *hornbills* and *toucans*, communicate indeed with their nares, which in these birds are very small; but it appears, in the fresh state, that the pituitary membrane closes this communication, and that it does not penetrate into these vacancies which are every-where traversed by osseous filaments.

Reptiles and fishes have nothing that can be compared to sinuses.

ARTICLE IV.

Of the Projecting Laminæ which increase the Internal Surfaces of the Nasal Cavity.

BESIDES the use of these laminæ in multiplying the internal surfaces of the nose, and thereby augmenting the extent of the pituitary membrane, and the intensity of the sensation of smell, they also form conduits which are joined to the apertures of the different sinuses.

A. In Man,

These laminæ are of three kinds, viz. the *ossa turbinata inferiora*, formed by particular bones; the *turbinata superiora*, which are productions of the *os ethmoides*; and its *anfractuosities*.

The

The *inferior turbinated bones* have the form of a thin lamina, which adheres by one of its edges to a ridge of the maxillary bone, and is slightly twisted in such a manner that the free edge points downward. Its convex surface is superior and internal. We observe that it is marked by some oblique furrows. The aperture of the maxillary sinus is above it posteriorly. The conduit formed by its concavity, proceeds directly from the anterior to the posterior nares.

The *os ethmoides* is formed of three laminæ perpendicular to each other, and of several intermediate laminæ. The *cribriform lamella*, which completes the cranium between the roofs of the two orbits, and the two *ossa plana*, each of which forms a considerable part of the internal parietes of the orbits, are the three external laminæ. We have already described them. See pages 20, 36, 48, and 61, of this volume.

Between the two *ossa plana* there is a single vertical lamina, which, continued with the *vomer*, divides the cavity of the nose into two parts. In the interval which it leaves on each side, there are some irregular lamellæ which adhere to the *os cribriforme*, and the *os planum* of the same side only, but not to the middle septum. These irregular lamellæ form communicating cells which we have named *anfractuosities*, and which may also be called *ethmoidal sinuses*. This collection of cells is closed, on the side of the septum, by a vertical and sulcated lamina. The
interval

interval which remains between these two laminae, leads directly to the sphenoidal sinus of that side.

The inferior part of the lamina, which is opposed to the septum, is prolonged obliquely, and extends a little posteriorly, where it forms a fold, the concavity of which is directed downward; and the anterior part is continued with a short canal, which ascending obliquely, and penetrating the ethmoidal anfractuosities, leads into the frontal sinus of the same side. This reflected lamina is the *superior os turbinatum*.

The two turbinated bones have a more spongy structure than the other osseous laminae; and we observe, particularly in the superior pair, that they contain a multitude of small holes.

B. In other Mammiferous Animals.

1. Of the *Ossa Turbinata Inferiora*.

We have shewn that these bones form only a simple lamina in man. We shall now describe their different degrees of complication in other animals.

They are similar to those of man in the *monkeys* of the old continent, but in *sapajous* they begin to resemble in structure those of the *Pachydermata* and *Ruminantia*; in all which animals the lamina is only simple at its base, and is bifurcated at a small distance. The two laminae which arise from it, are twisted spirally
on

on themselves. They incline from the side of the maxillary bone, and make two turns, or two and a half, according to the species.

The kind of horn or concha produced by this spiral turning, is closed posteriorly in a point. We know that it contains two canals, one above, the other below the principal lamina. The inferior leads, as in man, into the posterior nares. In the Ruminantia, the fissure which leads to the maxillary sinus, is found in the hollow of the superior canal. In the *bogs*, this canal is continued posteriorly by a long furrow, at the extremity of which there is a conduit which goes into the sinus in the base of the os malæ.

In *bogs*, the laminæ of the ossa turbinata are solid, but in the Ruminantia they are perforated by numerous foramina, more or less large. These foramina are small in *sheep*. They become very large and numerous in *deer*; and in the great Ruminantia, as *cows*, large *antelopes*, &c. their size is so considerable that they leave between them only osseous filaments, and the bone resembles lace.

The interior of these bones is divided by several vertical partitions, which are perforated like the rest of the septa.

In the *hippopotamus*, the two turbinated bones are flattened horizontally, but in other animals vertically. This is occasioned by the form of
the

the head. The foramina are very fine, and innumerable.

The inferior spongy bones are less regular in the Solipeda. The horizontal lamina, instead of bifurcating folds at first downward, then bends upward, and is attached behind to the maxillary bone. It ascends posteriorly to cover the foramen of the inferior maxillary sinus, and even to penetrate into it. Lastly, it produces, towards its middle, two or three oblique laminæ, which are attached to the anterior edge of this hole.

In the *ant-eaters*, the *pangolins*, the *oryzeteropus*, the *armadillos*, and even in the *three-toed sloth*, the inferior turbinated bones nearly resemble those of the Ruminantia. But in the *two-toed ant-eater*, they represent two prismatic boxes closed on all parts, the interior of which is divided by some vertical laminæ. We find two similar boxes in the *makis*, but no internal divisions.

Among the Rodentia, the *rat* has the turbinated bones similar to those of the Ruminantia; but the ossa turbinata of the other genera of that order, may be divided into two kinds: the first are formed like those of the Sarcophaga; the others, which are met with only in the *porcupines*, the *marmottes*, and a few other species, consist of a double lamina attached longitudinally, the two parts of which, separate from each other,

other, ascend by a spiral convolution, and represent a portion of the shell called *turbo*.

The other Rodentia, as the *hares*, *rabbits*, *squirrels*, *beavers*, *rats*, and the greater number of the Sarcophaga, as *dogs*, *bears*, *badgers*, *seals*, the *domestic cat*, &c. have a very complicated structure in the inferior turbinated bones. The lamina by which they are fixed is bifurcated. Each branch is again divided; the last lamina form, by their parallel situation, a number of small canals through which the air passes, and which are covered by the pituitary membrane.

The number of these laminæ is very variable. The *seals* and the *otters* are the species that have most of them. The *dogs* and *bears* rank next. Of all the Rodentia, the *beavers* have them most numerous, and the *hares* the least so.

The direction of the canals is most straight in the Sarcophaga, and most curved in the Rodentia.

When there are few laminæ, the last are spirally rolled as in the animals which have only two.

Some Sarcophaga have the inferior turbinated bones as simple as the animals first mentioned. The *lion*, for example, has only a bifurcation and a double roll, almost like the Ruminantia. The osseous lamina is pierced with many holes; the *civets* and *genettes* have a simple rolled bone without holes.

2. *Of the Ossa Turbinata Superiora, and of the Ethmoidal Cells.*

The ethmoidal cells, in a number of animals, are very distinct from the superior turbinated bone. The part of the nasal cavity which contains them, is sometimes separated from the rest by a particular septum. In *bogs*, this septum is formed inferiorly by a lamina which belongs to the palatine bones, and anteriorly by a projection of the ossa maxillaria, which goes to the septum of the nares, and only permits the air to pass by a narrow passage above it.

In the *horse*, this projection does not extend to the septum. It produces, however, a very evident separation, and leaves behind it a lateral depression, which is occupied by the ethmoidal cells. The same disposition prevails in the *Carnivora*, but neither in the *Ruminantia* nor the *Rodentia*, in which the depression is inconsiderable.

To form an idea of the ethmoidal cells in the greater number of animals, it is necessary to imagine a great number of hollow pedicles, all connected to the os cribriforme. They extend forward and outward, and, in proportion as they advance, those which are nearest unite. Vesicles arise from them, which increase in size in proportion as they become less numerous. They are all hollow, and there are an infinite number of conduits or ways between them, all of which commu-

communicate with each other. Such is their structure in the Edentata, the Ruminantia, the Solipeda, the Pachydermata, and the Sarcophaga. The latter of these orders have them the most numerous. The Rodentia have very few. The *porcupine*, for example, has only three or four on each side. Some genera, as the *hare*, have irregular cells, like those of man. Those of the quadrumana are similar.

The *superior turbinated bone* is represented in the Ruminantia, the Pachydermata, and the Solipeda, by one of the cells, which is larger, and in particular much longer than the others, and which extends to the inferior turbinated bone, which it covers in the manner of a roof. In the *hog*, it diminishes towards the lower part, and ends in a lamina, which is joined to the os nasi under its external edge. This edge, therefore, appears to be bent inwards to cover the inferior turbinated bone. The superior turbinatum becomes thin much higher up in the Sarcophaga, so that the hollow part of the cell, of which we speak, is not longer than in the other animals.

C. *In Birds,*

The external side of each nostril is occupied by three kinds of laminæ. The inferior turbinated bone is only a fold connected on one part to the alæ of the nose, and on the other to the septum. The middle or largest lamina, the fif-

ture of which Scarpa compares to that of a cucurbit, adheres by its bottom to the ossaceous part of the septum. It folds two and a half times on itself. The superior lamina, which has some resemblance to a bell, adheres to the frontal bone and to the os unguis. It contains two apartments, each of which is prolonged into a hollow tube. The most internal tube extends to the orbit, and the external terminates in a blind cavity behind the middle lamina. These three laminæ divide the nasal cavity into three passages. They vary in their magnitude and inflexions, according to the species. Scarpa, from whom we borrow this description, assures us that the middle makes only one turn and a half in the Gallinæ and the Passeres, and that the superior is in the same birds very small. It increases a little in the *pies*, is more considerable in birds of prey, and is still larger in the Anseres. Finally, in the Grallæ it alone occupies two thirds of the cavity, while the middle lamina is very slender, making only a turn and a half, and the inferior is only an indistinct fold.

These turbinata are in general cartilaginous. Harwood says, they are membranous in the *cassowary* and the *albatross*. To me they appear ossaceous in the *hornbill* and the *toucan*.

D. In Reptiles.

Reptiles have also different projecting laminæ
within

within their nose; but they are produced by the folds of the internal membrane, and are not sustained by osseous parts. The *tortoise* has three laminæ, which divide the nasal cavity into several fossæ. The middle one corresponds to the external aperture of the nostrils; between it and the next, there is an oblique canal which leads to the posterior nares. We find only some tubercles in *frogs* and other small species. It does not appear that any researches have been made respecting these parts in the *crocodile*.

E. In Fishes.

The internal laminæ of the nares in fishes are also entirely membranous; but they are more numerous and more regularly disposed than in the other classes. In the Chondropterygii, the *rays* and *sharks* have them placed parallel to each other on both sides of a large lamina, which extends from one end of the fossa to the other. Each consist of a semi-lunar fold of the pituitary membrane, and has other smaller laminæ situated on both its sides, in the same manner as it is placed with respect to the great middle lamina.

In the other fishes, whether cartilaginous or osseous, the laminæ proceed like radii from an elevated and round tubercle. They have a very elegant appearance in the *sturgeon*, where each is divided into more slender laminæ, as the branch

of a tree into smaller ramifications. In some species, and particularly in the *carp*, the middle tubercle is somewhat oval, and this renders the disposition of the laminæ more like that which prevails in the *Chondropterygii*.

ARTICLE V.

Of the Pituitary Membrane.

THIS membrane is a continuation of the external skin; it unites in the back of the mouth with that production of the same tegument, which, after investing the lips and all the interior of the mouth, covers the œsophagus and the rest of the intestines.

It takes the name of pituitary membrane in all the interior of the nose, on its septum, its parietes, its laminæ, and even in its sinuses. It is attached to the periosteum of all these parts by a compact cellular substance, and is itself every-where covered by the epidermis.

In the sinuses it is exceedingly thin, similar to a common membrane, and its vessels can scarcely be observed; but in the rest of the nose it is more thick and soft, particularly at the inferior and posterior part of the septum. Its substance is pulpy or fungous. We observe in it a spongy texture, rendered less compact in
small

small spots, which represent the meshes of a net. Its superficies is of a beautiful red colour, and it is only by examining it very closely that we perceive that colour to result from innumerable ramifications of small blood-vessels. We distinguish them better, however, near their trunks, particularly at the posterior part of the septum, or when they are distended by inflammation or injections.

The surface of this membrane has a great quantity of small pores, from which a mucous humour perpetually exudes. It is supposed that these are the orifices of an equal number of minute follicles concealed in the substance of the membrane. Many of these follicles have even been observed to exist in some parts, and to have common excretory canals. They were discovered by Stenon in the nares of the sheep. Ruisch, and after him Haller, perceived several to communicate with one common sinus, particularly towards the anterior part of the septum.

There have been observed in several quadrupeds, as the *cow* and the *sheep*, some parallel white lines between them. I have seen some of them transverse or oblique on the septum, and longitudinal on the inferior turbinated bones of the *sheep*.

A viscous humour constantly exudes from all parts of the pituitary membrane. In inflammations produced by colds, this at first becomes more abundant and fluid, and at last turns thick,

yellow, and disagreeable to the smell. The sinuses produce a more limpid fluid, which seems intended to dilute the other.

Except the Cetacea, of which we shall speak separately, the mammalia exhibit little difference in the structure of the pituitary membrane.

In birds, it is, according to Scarpa, very thin on the superior turbinatum. The vessels form a beautiful net-work on its surface, and a multitude of pores produce mucous matter in great abundance, particularly on the middle turbinatum, where the membrane is also more thick and villous.

In reptiles it is every where furnished with reticular ramifications of blackish vessels. We also find these black vessels in some fishes, and particularly in the *pike*; but in the greater number of species they are red. We observe between them some small papillæ, that secrete a thick mucilage, which appears to be more abundant in fishes, particularly in the *rays* and the *sharks*, than in the other classes.

ARTICLE VI.

Of the Nerves which are distributed to the Internal Parts of the Nose.

THESE nerves come from the first and the fifth pairs.

I. *The Olfactory Nerve.*

We have already described the origin of the first pair in man, page 148; in quadrupeds, page 164; in birds, page 168; in reptiles, page 170; and in fishes, pages 172 and 176 of this volume.

We have described all the portion of the nerve between its origin and its entry into the nasal cavity, by one or several foramina, in Lecture X. Article 1.; it remains for us now to treat of its passage through the cranium, and its distribution in the interior of the nose.

A. *In Mammiferous Animals.*1. *The Cribriform Lamella.*

The mammalia are the only animals that have a cribriform lamella to the ethmoid bone, and we must, even in them, except the Cetacea, which have neither an olfactory nerve, nor holes for its passage. All the other animals have only a simple hole, or a simple canal.

The position, and the concavity of the cribriform lamella, have been described in Lecture VIII. Article 3. § B: it now remains for us to speak of its size, its figure, and its foramina.

In man it has the form of an elongated rectangle,

U u 4

angle,

angle, and we reckon in it about 40 simple foramina. In *monkeys* it is proportionally much narrower, and its foramina are less numerous.

In the other quadrupeds, the cribriform lamella is shaped like a heart, or it is oval; it is placed at the bottom of a fossa, which a contraction, more or less conspicuous, separates from the rest of the cranium, and is perforated by a great number of holes of different sizes, collected in groups; these groups leave between them vacant spaces, disposed like the small and great branches of a tree, so that the whole lamella exhibits the appearance of very fine lace.

The number and figure of these clusters of foramina are not subject to constant laws; but, judging by the animals in which the sense of smell is known to exist, that sensation seems to be in proportion to the number of the holes.

They are large and numerous in the *elephant*, the *hippopotamus*, the *hog*, and still more so in the *hind*, or *female stag*. The *Sarcophaga* have them more numerous than all other animals. The *hog*, the *sheep*, and the *ant-eater* have, on each side of the crista galli, a range of holes which are larger than the others. We also find these holes, but less conspicuous, in some other species. The *Rodentia* appear, in general, to have fewer holes than the other orders. The *camel* has the lamella small, and the perforated spaces larger

larger than in the other Ruminantia. The Edentata have the lamella large, and furnished with many holes.

2. *The Olfactory Nerve.*

This nerve—whether it arise from the hemisphere, as in man, and in *monkies*—or whether the pia-mater unites it in such a manner to the caruncula mammillaris as to appear to form but one body with it, which takes place in the other quadrupeds,—always dilates, by its extremity, to cover the cribriform lamella, and to penetrate through it by as many filaments as that lamella has holes.

These filaments are distributed to the part of the pituitary membrane which covers the anfractuosities and turbinata of the os ethmoides, and to the intermediate septum of the nares: they are so very soft that it is difficult to trace them. We observe, however, some principal branches spreading over the septum. There are, in particular, two in the *sheep*, which are very beautiful. Several authors believe that this nerve does not extend to the inferior turbinated bones. Though we have not made particular researches on this subject, the complication of these bones in the animals which have the most acute sense of smell, would prevent us from adopting the same opinion.

B. *In Birds.*

The olfactory nerve in birds arises only from the anterior extremity of the hemisphere, which has been compared to the caruncula mammillaris of quadrupeds; it passes through a canal, the length and diameter of which varies according to the species, but which is not subdivided. On reaching the root of the nose, the nerve divides like a hair pencil into a multitude of fibrillæ, which expand in the pituitary membrane of the septum, and the superior turbinata. Scarpa is of opinion that they extend no farther, and supposes that the middle and inferior turbinata receive nerves only from the fifth pair, and are not organs of smell. The only use he attributes to them is that of breaking the force of the air, which these animals respire in a greater quantity than others, and thus preventing its shock from injuring the superior turbinata.

He states, that his experiments on living birds have convinced him, that smell is strongest in the species which have the superior turbinata and olfactory nerves the largest. The following is the order in which he places birds with relation to the faculty of smell, commencing by those in which that sense is most delicate—the *Grallæ*, the *Palmipedes*, the *Accipitres*, the *Picæ*, the *Passeres*, the *Gallinæ*.

C. *In*

C. *In Reptiles.*

The olfactory nerve in this class differs little from that of birds, as to its origin and its course; it differs still less in its distribution, since it also divides, according to Scarpa, upon the septum, and the superior turbinatum, without proceeding farther.

D. *In Fishes.*

When the olfactory nerve arrives behind the folded membrane which forms the naris, it is dilated to be applied to the whole of its internal and convex surface. Sometimes, before it expands, it swells into a real ganglion. This may be seen in the *carp*; at other times, its expansion takes place without any previous enlargement: it is thin, and may be compared to the retina, but we observe more distinctly the nervous fibres, of which it is composed. In *rays* and *sharks* there is a trunk under the principal fold of the pituitary membrane, and branches in the lateral folds; these branches produce small filaments, which penetrate into the substance of the membrane, where they are regularly distributed.

II. *The Nerve of the Fifth Pair.*

In all vertebral animals, the interior of the
nose

nose receives a ramification of the ophthalmic branch of the fifth pair, as we have shewn, page 206 of this volume, in man; page 209, in the other mammalia; page 220, in birds; page 222, in reptiles; and page 223, in fishes. This ramification is called the *nasal nerve*.

The *spheno-palatine* ganglion of the superior maxillary nerve furnishes, besides, in man and the other mammalia, several filaments to the posterior nares. See pages 210 and 211.

The maxillary sinus receives some ramifications from the same branch; and the frontal sinus, some from the frontal branch of the ophthalmic nerve.

In birds, the first nasal branch of the ophthalmic arises at the place where the nerve enters the bill; it is slender, and extends the whole length of the superior edge of the septum; the ophthalmic afterwards produces a second and larger branch, which divides into three or four ramifications, that extend to the middle and inferior turbinata. A third branch is distributed to the external parts of the margin of the nares.

The distribution of the fifth pair in the nose of reptiles, is not correctly known to us.

In fishes, the nasal branch of the ophthalmic is sometimes as large as the olfactory nerve itself. As these two nerves proceed a considerable way in a parallel situation in *carps*, the genus *gadus*, the *pike*, &c. some old anatomists (Collins
among

among others) believed that these animals had two olfactory nerves on each side : this error has been copied by several more recent writers.

The nasal nerve appears to us, to be principally distributed towards the external edges of the pituitary membrane.

ARTICLE VII.

Of the Cartilages which cover the Aperture of the Nostrils, and their Muscles.

WE have described, in page 82 of this volume, the aperture of the nasal fossa, as it exists in the skeleton, when the soft parts have been removed. In the fresh state that aperture is furnished with several cartilages, which more or less prolong the nasal cavity anteriorly, and which can enlarge or contract its entrance by their motions.

A. In Man.

I. The Cartilages.

The intermediate septum of the nostrils becomes cartilaginous at its anterior and inferior part, and is prolonged to the point of the nose ; its anterior edge is reflected upon the part which is immediately under the ossa nasi, in two triangular

angular laminæ, which extend to the side of the nose, and increase the planes formed by its proper bones.

The interval which remains on each side between these triangular laminæ and the septum, is occupied by an oblong transverse cartilage, reflected in two plates, between which is the vacant space that leads into each nostril; one of these folds is placed against the superior edge of the septum, the other occupies the substance of the *ala*, for such is the name given to the inferior part of each of the sides of the nose. The ala also contains, towards its root, one, two, or even three small irregular cartilages, which are sometimes membranous: all these parts are connected by a fat cellular substance, and covered by the skin.

II. *The Muscles.*

Several muscles act on these cartilages, and contribute, with the two lips, to give to the human countenance those various expressions which characterize it:

1. *The Pyramidalis Nasi.*

This muscle is a production of the occipitofrontalis, which descends between the eyebrows, and covers the sides of the nose; it is terminated by an aponeurosis, which is common to it with the muscle we have next to notice.

2. *The*

2. *The Transversalis, or Compressor Naris,*

Arises below the internal angle of the orbit, and extends along the side of the nose, to unite with its correspondent on the back of that part.

3. *The Levator Labii Superioris Alæque Nasi.*

This muscle descends from the internal angle of the orbit towards the lip, and, in passing, furnishes several fibres to the ala of the nose.

4. *The Depressor Alæ Nasi,*

Comes from the part of the maxillary bone which contains the dentes incisores, and extends directly upward to the inferior edge of the alæ nasi.

5. *The Nasalis.*

This muscle has its origin in the inferior part of the septum, and proceeds downward and laterally, to be confounded with the orbicularis of the lips.

The action of each of these muscles may be very easily comprehended.

B. *In other Mammiferous Animals.*

The cartilages of the nose and their muscles vary considerably in the mammalia, as well as the greater number of other external parts.

The cartilages of the nose of *monkeys* do not differ from those of man, but in their extreme smallness ;

smallness; they appear to have no muscles, except an expansion of longitudinal fibres, which uniformly covers the whole face, and which seems to be a continuation of the Panniculus Carnosus; this at least we have observed to be the case in the *macaques*.

In the Sarcophaga, in which the nose is not prolonged beyond the mouth, as, for example, the *dog*, the cartilages are also similar to those of man. The cartilage of the septum produces two alæ which prolong the bones of the nose, and the edges of the nostrils are furnished with two inflected cartilages: there are no distinct muscles, except the *levator communis alæ nasi, labique superioris*, which covers the whole cheek, almost in the same manner as the expansion we have described in the monkey; and the *depressor alæ nasi*, which is very small.

In the Sarcophaga, which have projecting and moveable snouts, as the *bears*, and particularly the *coatis* and the *moles*, the cartilages form a complete tube, which is articulated to the osseous nares.

In the *bear*, the cartilaginous septum is reflected inferiorly, as well as superiorly; the superior alæ bend downwards, the inferior upwards; they meet on the sides, where they are united by cellular substances, and complete the external parietes of each nostril. The edge of each ala continues afterwards to bend inward, and forms a kind of concha, which makes an
addition

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addition to the inferior os turbinatum, and which is covered, like it, by a prolongation of the pituitary membrane.

This cartilaginous tube is moveable, in every direction, on the end of the osseous snout: its muscles are particularly remarkable in the *mole*; there are four on each side, all attached above the ear, and extending between the temporal and the masseter muscles; they terminate by an equal number of tendons, which are placed round the nasal tube, like ropes round a mast: the most deep-seated of these muscles produces the superior tendon, which unites with its correspondent, and a large aponeurosis, which covers all the upper part of the nose. The two next muscles proceed to the side of the nose, the one a little higher, the other a little lower: the fourth, which is the most external, unites with the corresponding muscle under the nose, as the first does above it; these tendons are inserted into the fungous plate which terminates the snout, and cover the extremity of the cartilages: a small muscle also arises from the alveolar edge of the inter-maxillary bone, and depresses the snout. The end of the septum is ossified.

The snout of the *hog* is, in a great measure, similar to that of the *mole*; its cartilages are only proportionally shorter; their extremity is also ossified on the end of the septum: this animal has likewise four muscles to the nose, but

they are shorter, and differently situated; the superior arises from the os lachrymale before the eye; its tendon extends to the snout, but does not come near enough to the correspondent muscles to unite with it: two other muscles are situated under the preceding; they arise from the os maxillare before the zygoma, and partly unite, but their tendons proceed separately, the one to the side, the other towards the lower part of the snout: the fourth, which is very small, proceeds obliquely from the nasal bone, towards the insertion of the preceding muscle, and passes under the tendons of the two first.

The snout and its longitudinal muscles are enveloped in the hog, as in the mole, by annular fibres, which are a continuation of the orbicularis of the lips.

In the Solipeda and the Ruminantia, which have the osseous nares very open, directed obliquely upward, and formed by a large notch on each side of the point of the proper bones of the nose; a great portion of the soft part of the nares is membranous, and, in particular, bears the name of *nostrils*; the edge of their aperture only encloses a cartilage in the *horse*: this cartilage, called *semi-lunar* by Hippotomists, is analogous to the inferior cartilage of man, and is also formed of two branches; one almost parallel to the septum, which is long and narrow; the other, which is situated in the external

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ternal ala of the nose, is short, and almost of a square form: all the rest of the external ala is only a fold of the skin, which forms at first a blind cavity, the convexity of which is visible externally, and which is named the *false naris*. A long and narrow fissure of the internal parietes leads into the *true naris*: a principal muscle dilates the false naris. It is the *pyramidalis* of Hippotomists, and arises from the maxillary bone, near the origin of the zygomatic arch, by a narrow tendon; its fleshy part dilates, and is lost on the convexity of the false naris, and in the orbicularis labiorum: another muscle placed above the former, and arising from the os maxillare, near the notch of the osseous nares, penetrates into the fold situated between the bone and the false naris, and is inserted into a cartilaginous production of the inferior os turbinatum.

The semi-lunar cartilage is approximated to the septum, and the nostril is dilated by a muscle common to both nares, which is named *transversalis* by Bourgelot; its fibres are parallel to the orbicularis of the lips, from which no separation distinguishes them. Superiorly there are some fibres which arise from the nasal bone, and are inserted on the superior convexity of the false naris; they form the *musculus brevis* of Bourgelot.

The *musculus maxillaris* of the same author arises from all the anterior part of the forehead,

proceeds obliquely to one side, and downward, and is bifurcated; the external branch passes over the pyramidalis, and extends to the commissure of the lips; the internal passes under the pyramidalis, and intermixes with it, to be inserted in the external convexity of the false naris. Finally, the *levator labii superioris* may also be considered as a muscle of the nostril, on which it acts powerfully; it is a long muscle, which arises from the lachrymal bone; it produces a strong tendon, which unites with that of the correspondent muscle on the extremity of the ossa nasi, and forms with it an aponeurosis, which is inserted into the superior lip.

The muscles of the nose of the Ruminantia are much less complicated; their cartilages consist only of a duplicature of the septum, which is continued into the external ala of the nose by a pointed and arched production: the nostrils are not so far separate, and are directed more forward than in the horse.

There are two muscles on each side, which arise from the inferior part of the os maxillare, above the anterior molares; the superior divides into two tendons, one of which proceeds to the superior edge, and the other to the posterior angle of the nostril; the inferior divides into three other portions, which all go to its inferior edge: there is also a depressor; it is situated anteriorly.

We shall terminate this description of the cartilages

tilages of the nose, and their muscles, in mammalia, by that of the proboscis of the elephant.

The following description is the substance of that which was given by the Academicians of Paris :

The proboscis of the elephant is a very elongated cone, broadest at the root. Its interior is hollow, and divided into a double tube, covered with a strong tendinous membrane, and perforated by a number of small holes, which are the orifices of an equal number of mucous cryptæ, and from which a liquid flows in great abundance. These tubes ascend to the osseous nares; but a little before they arrive there, they are twice inflected, and their communication with the nares is closed by a cartilaginous and elastic valve, which the animal can open at pleasure, and which falls down by its own elasticity when the muscles cease to act upon it.

All the interval between the membranous tubes which are in the axis of the proboscis, and the external skin, is occupied by a very thick fleshy layer, composed of two kinds of fibres. Those of the first kind extend from the membrane of the tubes, to a tendinous membrane situated under the external skin, in such a manner that they appear transverse upon a longitudinal section of the proboscis, and that in a transverse section they represent the radii of a circle. They approximate the external skin and the membrane of the tubes, and, by compressing

the intermediate layer, produce the elongation of the proboscis, without narrowing the tubes, in the manner of annular fibres; a mode of action which is very remarkable. The other fibres of the proboscis are longitudinal: they form a number of short and arched fasciculi; the two extremities of which are attached to the membrane of the tubes, and the middle or convexity of which adheres to the external membrane. There are some of these fasciculi all along and around the proboscis. The effect they produce is to shorten it wholly, or in any particular part, as the animal pleases.

It will be easily conceived, that these partial elongations and contractions, on either side, enable the elephant to give to his proboscis any imaginable flexure; but that which is most difficult of explanation, is the manner in which he conveys to his mouth the water which he has taken into his trunk. As there are no annular fibres, he cannot compress the tubes, and he has no other means of impelling it forward but by respiration; but how can this be done at the moment of swallowing? Perhaps the end of the proboscis is conveyed beyond the opening of the larynx.

We have dissected only the fœtus of an elephant, which has however enabled us to add some facts to the preceding description. All the small longitudinal fasciculi belong to four large muscles, which are almost confounded in the

the proboscis, but are sufficiently distinct at their superior attachment. The two anterior are connected, by the whole of their breadth, to the frontal bone above the *ossa nasi*; the two lateral adhere to the maxillary bones, under and before the eye. The posterior, or inferior surface of the proboscis, is furnished with fibres which seem to be continued with those of the orbicularis of the lips. They are directed from above downward, and from within outward; so that those on one side form a figure like an Λ , with those of the other.

All these muscles are supplied by a very large branch of the sub-orbital nerve, which penetrates, on each side, between the lateral and inferior muscles, and ramifies through the whole proboscis.

The proboscis of the *tapir*, which we have also dissected in a foetus, resembles in some respects that of the elephant, though it is much shorter. It is also composed of two membranous tubes, furnished with a number of mucous lacunæ, and enclosed in a fleshy mass enveloped by the skin. The longitudinal fibres are divided only into two fasciculi, which arise below the eye. The transverse fibres extend, as in the elephant, from the membrane of the tubes, to that which is under the skin; but the *tapir* has, besides, a muscle similar to the *levator labii superioris* of the horse. It arises in the same manner from the parts adjacent to the

X x 4

eye,

eye, and unites in a common tendon with its correspondent muscle above the nostrils. The occipito-frontalis also furnishes a tendon which is inserted at the base of the proboscis, and elevates it.

C. *In Birds.*

The external nares of birds have neither moveable cartilages nor muscles. Their aperture is merely contracted by productions more or less considerable, of the skin which covers the bill. The forms and positions of that aperture have been described by naturalists. It is situated laterally in the greater number of birds. Some have it at, or even on, the base of the bill. The *toucans* afford an example of the latter case. It is sometimes broad, sometimes narrow. In the *herons*, for example, it is a fissure into which a pin could with difficulty penetrate. In the *sea-swallows*, the two nares correspond to an aperture of the septum, so that we can see through them across the bill. The *Gallinæ* have the nares partly covered by a fleshy plate. The *ravens* have them closed by a fasciculus of stiff feathers directed forward, &c.

D. *In Reptiles.*

The external nares of reptiles are usually furnished with only some fleshy strata, which dilate or contract their entrance. This is observable

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servable in the greater number of *lizards*, which differ from each other only as to the position of their external nares. They are closest to each other in the *crocodiles*. The *tupinambis*, the *stellions*, and the *camelions*, have them more removed, and situated more laterally. In the *salamanders* they are exceedingly small. In *frogs*, we observe a small tube, the motion of which is very apparent, because it is extremely useful in respiration, as will hereafter be shewn. The *tortoises* have also two very small approximated nostrils. In the *matamata*, and one or two other species, they are situated at the end of a short cartilaginous proboscis.

Serpents have small lateral nares, which are capable of only a slight extension. The *rattlesnake* has below and behind each naris a blind hole, pretty deep, the use of which is not known, but it gives the animal the appearance of having four nostrils.

E. In Fishes.

In fishes the entry of the fossa, which forms each naris, is narrower than the fossa itself. The membrane which surrounds it, is, in a number of osseous fishes, and particularly in the *carp*, capable of forming a short tube, at the will of the animal; but when the fish is drawn from the water, this tube disappears.

The greater number of osseous fishes have the nasal aperture divided into two parts by a membranous

branous bar, and this gives them the appearance of having four nares. The two holes on each side are sometimes equal and sometimes unequal. They are infinitely various in size and in position, but these external differences have been described by Ichthyologists.

In the Chondropterygii, the nares communicate by a groove with the angles of the mouth. A part of their aperture is commonly covered by a lobe of the skin, and the muscular fibres which open them, are attached to the bones of the jaws. They appear to be contracted by a sphincter. It is difficult to observe either distinctly.

ARTICLE VIII.

Of the Nares and the Spiracles of Cetacea.

THE nares of the Cetacea merit a particular description, on account of their great difference from those of the other Mammalia.

The Cetacea can respire only in air; but they cannot receive it by the mouth, which is more or less sunk in the water, and could not have taken it in by the nares, if their aperture had been situated at the end of the muzzle; for this reason their nostrils open on the summit of the head, which these animals can easily elevate
above

above the surface of the water. They form, therefore, their only means of respiration. They serve besides to discharge the water, which they would be obliged to swallow every time that they open their mouth, if they had not the means of ejecting it through their nares, by a mechanism which we shall presently describe.

The common pituitary membrane would doubtless have been irritated by this constant and violent passage of salt water, as we may easily conceive, from the disagreeable sensation we feel when a few drops of the liquor we drink enters our nose. On this account the nares of the Cetacea are lined by a thin dry skin, which has neither cryptæ nor mucous follicles, and which does not appear fitted to exercise the sense of smell. There are no sinuses in the surrounding bones, nor any internal projecting laminae. The os ethmoides is not even perforated by any hole, which indeed is not necessary, as the olfactory nerve does not exist. (See pages 165 and 199.) It is not, however, certain that these animals have no smell; but if that sense exist, it must reside in a cavity we are about to describe.

We have shewn in page 503, that the Eustachian tube ascends towards the nares. The part of this canal which is next the ear, has, at its internal surface, a pretty large hole, which leads into a large vacant space situated deeply between the ear, the eye, and the cranium, main-

tained by a very compact cellular substance, and prolonged in different membranous sinuses which are attached to the bones. This sac, and these sinuses, are lined internally by a blackish, mucous, and very tender membrane. It communicates with the frontal sinuses, by a canal which ascends before the orbit. Those sinuses have no immediate communication with the nares, properly so called. We find in this sac, as well as in the nares, nerves proceeding only from the fifth pair. Hunter states, that he had observed something similar in two species of whale, but he did not suppose that the organ of smell was to be seen in the *dolphin* and the *porpoise*, from which we have taken this description.

The following is the mechanism by which the Cetacea eject the water in those spouts by which they are recognised from a distance at sea, and which have procured to several species the name of *blowers*.

If we trace the œsophagus upwards, we find that, when opposite to the larynx, it seems to divide into two conduits, one of which is continued into the mouth, and the other ascends into the nose. The latter is surrounded with glands and fleshy fibres, which form several muscles; some, which are longitudinal, are attached to the margin of the posterior orifice of the ossicous nares, and descend along that conduit to the pharynx and to its sides: the others are annular, and seem to be a continuation of the
proper

proper muscle of the pharynx. As the larynx rises in this conduit in the manner of an obelisk or pyramid, its annular fibres may close it by their contractions.

All this part is provided with mucous follicles, which pour out their liquor by very conspicuous foramina. When arrived at the vomer, the internal membrane of the conduit, which becomes that of the osseous nares, acquires the even and dry texture which we have already described. The two osseous nares are closed at their superior or external orifice, by a fleshy valve in the form of two semi-circles. This valve is attached to the anterior edge of the orifice, and closes it by the means of a very strong muscle situated upon the intermaxillary bones. In order to open it, an extraneous force must be applied from below. When this valve is closed, it intercepts all communication between the nares and the cavities situated above it.

These cavities are two large membranous sacs, formed by a black and mucous skin; they are full of rugæ when empty, but when full assume an oval form. In the *porpoise*, each is of the size of a drinking-glass. These two sacs are situated under the skin, before the nares. They are both continued into an intermediate cavity placed upon the nares, which opens externally by a narrow fissure, in the form of an arch. Some very strong fleshy fibres form

an expansion which covers all the upper part of this apparatus. They arise in radii from the circumference of the cranium, and unite upon two sacs, which they appear capable of compressing very powerfully.

Let us now suppose, that one of the Cetacea contains in its mouth a quantity of water which it wishes to eject: the animal moves the tongue and the jaws, as in the action of swallowing, and closing the pharynx, forces the fluid to ascend in the conduit and the nares, where its motion is so much accelerated by the annular fibres, that the valve is raised, and the two sacs above it distended. When the water is in the sacs, it may remain there until the animal is inclined to eject it. For this purpose, the valve is closed, to prevent the water from descending into the nares, and the sacs are strongly compressed by the muscular expansions which cover them. The fluid is then thrown out through the narrow crescent-shaped aperture, and rises to a height corresponding to the force of the pressure.

It is said that *whales* eject water to the height of 40 feet.

ARTICLE IX.

*Of the Organs of Smell in Animals that have no
Vertebræ.*

WE do not find the nose, properly so called, nor even any organ which appears evidently appropriated to smell in invertebral animals, and yet almost all of them afford very striking proofs that they possess this sense.

Insects discover their food at a distance. Butterflies seek their females, even when inclosed in boxes, and as they are liable to be deceived by resemblances of odour, it is evident that these insects are guided in many circumstances by the sense of smell. Thus the *flesh-fly* (*musca vomitoria*) lays its eggs on plants that have a foetid smell, imagining that it places them on corrupted flesh, and the larvæ which are thus produced perish for want of their necessary food.

As the organ of smell, in all animals which respire air, is situated at the entrance of the organs of respiration, the most probable conjecture that has been proposed respecting its seat in insects, is that of Baster, since revived by several naturalists, who placed it in the mouths of the tracheæ or air tubes. In addition to the reasons hitherto stated in support of this opinion, we may observe, that the internal membrane of the tracheæ appears very well calculated

lated to perform this office, being soft and moistened, and that the insects in which the tracheæ enlarge, and form numerous or considerable vesicles, are those which seem to possess the most perfect sense of smell. Such are all the *scarabæi*, the *flies*, the *bees*, &c.

The antennæ, which other anatomists have supposed to be the seat of smell in insects, do not appear to us to possess any of the conditions requisite for that organ.

The mollusca, which respire air, may also possess the sensation of smell at the entrance of their pulmonary vessels; but it is not necessary to search for a particular organ of this sense in them, as their whole skin appears to resemble a pituitary membrane. It is every where soft, fungous, and is always moistened by a great quantity of mucous matter. Finally, it is supplied with numerous nerves, which animate every point of its surface.

The worms and soft zoophites, and all the polyps, are probably in the same situation. It cannot be doubted but that these animals enjoy the sense of smell. It is chiefly by it that they discover their food, particularly the species that have no eyes. Aristotle remarked, that certain herbs, which have a strong odour, were avoided by *cuttle-fishes* and the *octopus*.

SECTION SECOND.

OF THE ORGANS OF TASTE.

ARTICLE I.

Of the Sensation of Taste.

HAVING treated so fully of the four preceding Senses, little remains to be said respecting that of Taste, which is the least removed from the ordinary sense of Touch.

The organs of these two senses are, indeed, so much alike, that they may serve for the mutual explanation of each other. Recourse may be had to the organ of Taste, in order to obtain an idea of parts which are not sufficiently developed for our observation in that of Touch.

The organ of Taste is particularly characterized by its spongy texture, which enables it to imbibe liquids. The tongue can only taste substances which are liquid, or are susceptible of fluidity when dissolved in the saliva. Insoluble bodies are tasteless. The most sapid even make no impression on the tongue, when it is dry in consequence of sickness, or when the

saliva, consumed by previous mastication, has not had time to be renewed.

Nature has provided plentifully against this want, by a constant moisture.

In all animals which do not live in water, numerous glands pour an abundance of fluids into the mouth, as we shall see when we treat of Mastication. The total absence of saliva, and perfect dryness of the tongue, is one of the most painful sensations that can be experienced.

The taste of bodies seems to be greater in proportion as they are more soluble: salts possess it in the highest degree; but it will be easily conceived, that it is impossible to account for the different kinds of flavours attached to each body, and that the explications, founded on the figures attributed to their elementary particles, cannot now be admitted. The change which takes place on the nerve, is doubtless the effect of the reciprocal action exercised between the principle of each taste, and the nervous fluid; but the nature of that action is still unknown to us, and of its connection with the image which results from it, we must necessarily be always ignorant.

The sense of taste in any animal is more perfect—1st, in proportion as the nerves, which proceed to the tongue, are more considerable: 2d, as the teguments of that part are more capable of being penetrated by sapid substances: 3d, as the tongue itself is more flexible, and

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can be applied to a greater superficies, and embrace more closely the substance which the animal wishes to taste.

In the following Articles we shall consider the Organs of this Sense, under these three points of view.

ARTICLE II.

*Of the Substance of the Tongue, of its Form,
and of its Mobility.*

THE tongue is at the same time an organ of taste, of deglutition, and of speech; but as the parts which serve to move it, contribute more to the two last functions than to the first, we shall not notice them at present. In the Article on Deglutition, we shall describe the os hyoides, its ligaments, and its muscles, as well as the muscles of the tongue, and the motions of which that organ is susceptible. We shall, in this place, only explain the nature of its substance, and the degree of its general mobility, in so far as it possesses an influence on the perfection of taste.

In all mammiferous animals without exception, the tongue is fleshy and flexible in all its parts, attached by its root only to the os hyoides,

and by a portion of its base to the lower jaw ; it differs only as to the length and extensibility of its free part or point. The extremes in this respect are the *ant-eater*, which can elongate the tongue exceedingly, and the *Cetacea*, which have it attached by almost the whole of its inferior surface.

The other species present no material difference from man, with regard to these circumstances.

In *birds*, the tongue is always supported by a bone, which passes through its axis, and is articulated to the os hyoides ; it is consequently very little flexible : the point only of the bone, which becomes in a degree cartilaginous, is capable of flexion. The shape of this bone corresponds to the external figure of the tongue, being covered only by some muscles, and by the teguments which are thin. In the *wood-peckers*, and the *wry-necks*, it is considerably shorter than the skin of the tongue. When their tongue is elongated, therefore, the os hyoides, and its cornua, extend forward, and penetrate into this surplus of the skin, which is thereby extended, and the tongue pushed forward, as we shall shew hereafter.

Reptiles vary greatly with respect to the tongue, as well as in many other circumstances. The tongue of *toads* and *frogs* is entirely fleshy, attached to the lower jaw, and, in a state of repose, inflected in the mouth.

In *salamanders*, it is attached as far as the point, which is not moveable, and the whole tongue is only free on its lateral parts. *Crocodiles* have it attached as close to the edges as its point, and authors long supposed that this animal had no tongue. It is entirely fleshy in both these genera.

The *stellions* and the *iguanas* have a fleshy tongue, which possesses nearly the same mobility as that of the mammalia. The *scinks* and *geckos* differ only in having the tongue notched at the extremity, and in that respect it resembles the tongue of *slow-worms*, to which, in general, the *scinks* are very much allied.

In *common lizards*, the *tupinambis*, or *monitor*, &c. the tongue is singularly extensile; it terminates in two long flexible points, though semi-cartilaginous; it completely resembles that of serpents, if we except the *slow-worms* and the *amphisbena*, which cannot elongate their tongue, but which have it flat, and only forked at the extremity.

The *camelion* has a cylindrical tongue, which may be considerably elongated by a mechanism analogous to that which takes place in woodpeckers.

In some *fishes*, as the *Chondropterygii*, there is no tongue at all; the lower part of the gullet is smooth, and has no elevation.

In *other fishes*, as the greater number of those that have *free branchiæ*, the tongue is formed

only by the protuberance of the middle bone, to which those that support the branchiæ are articulated; that bone has no muscles, except those which elevate or depress it in deglutition and respiration; none of its parts are capable of flexion; it is covered only by a more or less thick skin, and is frequently furnished with teeth, which are either sharp, or in the manner of a pavement, and which render the surface almost insensible.

The *syren* resembles, in this respect, the fishes that have free branchiæ.

The *sepia*, the *snails*, and the greater part of the *gasteropodous mollusca*, have a cartilaginous tongue, the very singular structure of which we shall explain hereafter; it has no motions, except such as are connected with deglutition; its anterior part is fixed below the mouth, and it is incapable of embracing solid bodies.

The *acephalous mollusca* do not appear to have any tongue; perhaps they exercise the sense of taste by those tentacula, so similar to papillæ, with which their cloaks are furnished, at the parts where the water, which is the vehicle of their aliments, enters.

There is no tongue, properly speaking, in *worms*, though some have given that name to the proboscis of the *thalassema*, the *echinorbineus*, &c. The *zoophites* have also no tongue; but the tentacula, which surround their mouth, are frequently so fine, and of so delicate a substance,

as

as to be very well calculated for the feat of taste. Besides, why may not the whole skin of the *polype* be sufficiently sensible to discern saline substances dissolved in water, since it is capable of feeling the light which passes through it?

The numerous class of *insects* presents great varieties with regard to the organs of taste.

The *coleoptera*, and the *orthoptera*, have the part which has been named, perhaps without much analogy, the inferior lip horny at its base, and terminated at its point by a membranous expansion, which is, in particular, named the *tongue*: the form of this tongue is infinitely various in the different genera, as may be seen by consulting the works of late Entomologists. The pharynx opens at the base of the tongue.

The *hymenoptera*, and some *neuroptera*, have the tongue situated at the same place; but it is concave, and perforated for the pharynx inferiorly, and is frequently prolonged into a proboscis, which sometimes surpasses the length of the whole body; this proboscis also preserves the name of tongue; it is membranous, but we observe that its substance is soft and fungous, and that it is very well fitted for receiving the impressions of taste. Accordingly we remark that the insects, in which it is most developed, are the most distinguished for the choice of their aliments. The *bees* afford an example of the truth of this observation.

All the *diptera* with a fleshy proboscis, as the *flies*, the *tabanus*, &c. seem also to have an excellent organ of taste: the two lips of their proboscis, independent of their soft substance, and the delicacy of their teguments, have the faculty of embracing several points of sapid bodies.

The *lepidoptera*, or *butterflies*, have a tubular tongue; it consists of two pieces, exactly joined, and very often of a considerable length, and may be capable of distinguishing very accurately the nature of the liquor it sucks up, if the whole of the canal be sensible to that sort of impression. The same observation may be applied to the sucker of the *ryngota*, or *hemiptera*, and that of the *diptera*, which have not a fleshy tongue, as the *asilus*, the *stomaxys*, the *culcx*, &c. We cannot, however, judge of the perfection of each of these instruments, merely by their proportional extent. It would be necessary to take into the account the degree of their particular sensibility, which cannot be estimated in organs so minute.

The *cirri*, the *palpi*, or *antennulae*, are filaments more frequently articulated, and attached to certain parts of the mouths of insects, and which these animals constantly move, for the purpose of touching their food while they eat. Some authors have supposed them to be appropriated to the sense of taste, some to that of smell, and, finally, others believe them to be
simple

simple organs of touch.: different as these opinions may be, it is not impossible that these organs may not perform at once two or several functions. It is obvious, however, that this is a subject upon which we never can arrive at certainty. We shall describe these Palpi along with the rest of the organs of Manducation in insects.

ARTICLE III.

Of the Teguments of the Tongue.

A. In Man.

THE muscles which form the internal fabric of the tongue, are surrounded by a considerable quantity of cellular substance, and covered by a thick membrane, which is the continuation of that which lines the interior of the mouth, and consequently of the external skin of the body.

The particular characters of this membrane on the tongue, are the thickness and softness of the part analogous to the epidermis, but, above all, the extraordinary development of the papillæ, which, though essentially of the same nature as those of the external skin, are much larger, more close, and afford a more complete view of their intimate structure.

All the superior surface of the tongue, from the point to nearly its root, is covered with papillæ, called, on account of their figure, *conical*; they are close, like the bristles of a brush; on the middle of the tongue, and towards its point, they are sharp and elevated, and their extremity is divided into several filaments; towards the sides they become gradually shorter, and are reduced to simple blunt tubercles.

Among these papillæ others are distributed, which are larger, but much less numerous; these are called *fungiform* papillæ; they are placed on a small pedicle, and terminate in a large round head; there are more of them towards the end of the tongue, than in any other part.

Lastly, towards the base of the tongue there are about ten semi-spherical tubercles, each surrounded with a circular fold or burr, and on that account called *papillæ in a calyx*, or *incupped papillæ*; they are disposed in two lines, which represent a V with the point turned towards the throat.

The space situated between the point of this V and the epiglottis, has no papillæ, but the membrane is rendered unequal by glands which are below it; and we observe that the greater part of its eminences are perforated by holes, through which fluids, prepared by these glands, pass into the mouth; the inferior surface of the tongue has also no papillæ, and its skin does not differ from that of the rest of the mouth.

The

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The part analogous to the rete mucosum is so thin on the human tongue, that we can scarcely recognize its existence; but it is very thick on that of quadrupeds, where the papillæ, which pass through it, render it completely reticular.

B. *In other Mammiferous Animals.*

The tongue of the other mammalia presents the same kind of papillæ as that of man: the difference consists merely in the form of the conical papillæ, and of the substance with which they are sometimes armed, in the size and abundance of the fungiform papillæ, in the number of the incupped papillæ, and the figure which their arrangement represents.

In the *guenons*, we observe no difference from the human tongue, except that the papillæ with a calyx are less numerous. The *Chinese monkey* has seven disposed in this manner: The *macaque* has four situated thus; the *cynocephalus* and the *mandrill* have only three, which are ranged triangularly . . . We also find only three in the *sapajous*, which are farther distinguished by the little prominence of their conical papillæ.

Several *bats* have the conical papillæ elongated, and almost resembling hairs; these are particularly observable towards the posterior part of the tongue: some of them are also found on
the

the sides of the mouth. These papillæ are as hard as horn in some species, as the *ternate bat*, in which the papillæ of the extremity of the tongue have each several points; there are only three papillæ with cups on the tongue of these animals, and they are very close together.

The *cat* genus has the teguments of the tongue of a very particular nature: all the edges of that organ are furnished with small soft conical and with fungiform papillæ, similar to those of the greater number of animals; but all the middle part is covered by other papillæ, which may be divided into two kinds; some are rounded, and, when a little macerated, represent fasciculi of filaments, which seem to be the last extremities of the gustatory nerves: the others are conical, pointed, and each covered with a horny case, terminating in a point, which is inflected backward; these cases render this tongue so extremely rough, that it tears off the skin by licking; they may be easily plucked out, and have then the appearance of so many small claws. The filamentous papillæ and the horny points are placed alternately in quincunces, so that there are as many of one kind as of the other. There are no fungiform papillæ in all this space: I believe they are replaced by the fascicular, as the conical are by those with the horny cases. The posterior part of the tongue assumes the nature of the ordinary teguments: the papillæ with cups are proportionally

tionally smaller than those of the other genera, and disposed in two lines, which approach posteriorly. In the *common cat* we sometimes observe on the back part of the sides of the tongue, some fungiform papillæ dependent from very long pedicles. *Civets* have a tongue similar to that of cats.

The *opossums* have also, at the middle and anterior part, horny cases, or scales inflected backward, but they terminate in wedges, or in rounded edges; the point of their tongue is denticulated like a fringe; there are only three incupped papillæ. The *phalangers* have the tongue soft, like the other *Sarcophaga*. *Dogs*, *bears*, *weasels*, *seals*, &c. all of which scarcely differ from man in this organ, and differ from each other only as to the number of the papillæ with cups.

There are five of these papillæ in the *martin*, ten in the *raccoon*, two large and some very small ones in the *badger*. I have only been able to reckon four very small ones in a large *dog*; there are only three, which are very large, in the *hyæna*. All the space situated between the incupped papillæ and the epiglottis is furnished with large conical papillæ, which are very acute, and more close together

One of the most singular tongues among the Rodentia, is that of the *porcupine*: on its sides, and towards the extremity, it has some large scales, with two or three points terminated like
wedges.

wedges. The rest of the surface resembles that of the tongues of the other mammalia; there are only two large papillæ with cups. The other Rodentia do not differ from man, except in having fewer of those papillæ.

The long-nosed Edentata, as the *ant-eaters*, *armadillos*, *oryzeteropus*, all have the tongue long, narrow pointed, and singularly smooth: in the two latter, the conic papillæ are not distinctly seen; except with a magnifying glass; and in the *ant-eaters*, properly so called, none are perceptible. There are but three papillæ with cups in the *oryzeteropus*, and only two in the *armadillos*.

The *sloths* have the tongue round at the point. The conic and fungiform papillæ little developed, and only two incupped papillæ.

The tongues of the Pachydermata have the papillæ little evident.

In the Ruminantia, the conic papillæ, which cover the anterior half of the tongue, are numerous, close and fine; each terminated by a horny but flexible filament, which is bent backward. These filaments can only be distinguished by a glass in *sheep*, *gazelles*, &c. But in the *camel* genus they are long, and render the tongue soft to the touch like velvet. The posterior part of the tongue of these Ruminantia is covered with thick tubercles, which sometimes resemble short cones, and sometimes are semi-spherical, and which become smaller towards

wards the sides. The papillæ with cups are ranged on the sides of this posterior part; they are pretty numerous, and cannot be easily distinguished from the fungiform, which are equally large in this part. The *camel*, however, must be excepted, which has the incupped papillæ very large, and concave on their surface.

In the *horse*, the conical papillæ are very small and compact; the fungiform are only found on the sides of the tongue; there are only three incupped papillæ, the surface of which presents a multitude of irregular tubercles. The space situated posteriorly resembles the corresponding part of the human tongue.

There is no distinct conical papillæ observed, even with a glass, either on the tongue of the *dolphin* or *porpoise*: that organ is, in these animals, covered, as it were, with small pimples, which are most numerous at its posterior half: we observe at its base four fissures, disposed nearly as the papillæ with cups usually are; the edges of its point are divided into small, narrow, and obtuse shreds.

C. *In Birds.*

The tongue of birds has papillæ of different forms: some are fleshy, blunt and rounded; others are covered by horny cases, which are sometimes conical, sometimes cylindrical; others again are osseous and cartilaginous. The
latter

latter kind is almost always found at the posterior part of the tongue. They are directed backward, and seem rather intended to assist deglutition, by preventing the return of the food, than to exercise the sense of taste.

Vultures have the tongue rounded anteriorly, and horny at its external third. All its surface is smooth, except the edges, which are serrated, and raised as if it were to form a canal. Each denticulation is invested by a cartilaginous case directed backward.

The tongue of *falcons* is thicker, entirely smooth on the edge, and notched on both its extremities.

The nocturnal birds of prey have the tongue fleshy, and furnished posteriorly with soft conic papillæ directed towards the throat.

In *parrots* the tongue is very thick, fleshy, and rounded anteriorly. We observe on it some papillæ, which are really fungiform, particularly at the posterior part.

That of *toucans* is narrow, and furnished on each side with long and close horny bristles, which give it the appearance of a feather.

The *woodpeckers* and *wrynecks* have the tongue formed of two parts; one is anterior, protractile, and smooth. It is pointed anteriorly, and covered with a horny sheath, and furnished on its edges with four or five stiff spines directed backward, which renders it a kind of harpoon or barbed arrow. The other part of the tongue
is

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is loose, and serves as a sheath to the os hyoides and its cornua, when the tongue is elongated. Its surface is covered with small spines directed backward. Each of these spines appears to be implanted in the centre of a fleshy tubercle. The aperture of the glottis is contained in the loose part of the tongue.

The *Gallinæ* have the tongue pointed, cartilaginous, and in the form of the head of an arrow. Its surface is smooth and without any kind of papillæ, except upon the posterior part.

There are also no papillæ on the tongue of the *ostrich*, which is crescent-shaped, broad, and so short that several authors have supposed it did not exist. Its base is a fold of the skin, which supplies the place of the points in other birds.

The *jays*, the *flares*, and a great number of passerine birds, have the tongue similar to that of the gallinaceous family; but in several genera the point is more or less cleft, divided into several small bristles, or appears lacerated. Naturalists have founded the characters of some of their genera of birds on the differences of the tongue, and may be consulted as to its forms. We also observe a slight furrow, which extends throughout the whole length of its middle part.

The *duck* genus, in which the tongue is fleshy, flat, and broad, presents a number of varieties as to the disposition of the papillæ.

In the *swan* there is a deep furrow formed in

the middle of the tongue. The surface of the anterior part is covered by a thick layer of stiff and compact hairs directed towards the sides. Farther back, and towards the middle part along the furrow, there are three rows of plates or ossaceous laminae, the base of which is thick, and the sharp edge free and turned backward. More posteriorly, there are some conic papillae in the form of short stiff hairs, which are also directed backward. Two other lateral furrows separate the hairs from another range of ossaceous lamina, similar to those of the middle part, but augmenting in breadth in proportion as they approach the base of the tongue.

The edges of the tongue are besides furnished with long stiff parallel bristles, situated very close to each other, and resembling the teeth of a comb.

Towards the posterior third the tongue seems divided by a considerable tubercle, the surface of which is rugous, but has no papillae. Behind this tubercle the surface is covered with thick, long, and fleshy papillae, directed backward. Deep furrows, in the form of an italic s, separate them from each other.

The surface of the tongue of the other species of ducks varies considerably. The *Br. argus* has also two ranges of ossaceous laminae. In the *argus* *anas penelope* there are none, except on the edges of the posterior third. Almost all the species have the villi stiff, and directed towards

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wards the sides. In the *velvet duck*, (*anas fusca*,) they extend considerably beyond the edges of the tongue.

In the *eider duck*, (*anas molliſſima*,) the point of the tongue has a small, round, flat, and horny appendix. The anterior villi are shorter, and the posterior surface is almost smooth.

In the *grallæ*, the tongue, which is a more or less elongated triangle, or in the form of an arrow, is generally smooth and flat.

In the *bustard*, the shape of the tongue approaches that of the *grallæ*. It differs, however, in having its edges furnished with long horny stiff papillæ, the two last of which are very broad, sharp, and as it were ossaceous.

D. In Reptiles.

The tongue of the *tortoise* is furnished superiorly with long, soft, close, conic papillæ, which give it the appearance of velvet.

In the *crocodile* they are very short, and represent rather slight rugæ than papillæ. They form, on the contrary, a very distinctly villous surface in the *iguanas* and the *stellions*. The tongue of the *camelion* is furnished with deep, close, and very regular transverse rugæ; in the *lizards*, with extensile and forked tongues; and in the *serpents*, that organ is singularly smooth, and, as it were, horny towards its points.

The *salamanders* have, like the *iguanas*, a fine

villous surface to the tongue ; but in the *frogs* and *toads*, the surface is perfectly smooth to the eye, and always mucous.

No reptile has two kinds of papillæ, nor glands with a calyx.

E. *In Fishes.*

The skin which is applied to the bones that sustain the tongue of fishes, resembles that of the rest of the mouth, and does not present to the eye more developed papillæ. The only differences that can be remarked, belong to the teeth, with which the tongue is armed in certain species, and which we shall describe when treating of Mastication.

We also reserve the description of the Tongue, or the organs which replace it, in white-blooded animals, until we come to the same Article.

ARTICLE IV.

Of the Distribution of the Nerves in the Tongue.

THE sense of taste differs from those of sight, hearing, and smell, and resembles that of touch, in having no one pair of nerves entirely appropriated to its functions. The tongue receives
branches

branches from three different pairs in warm-blooded animals, and two only so far as we have observed in fishes, but they are not all employed in this sensation. Those which come from the *hypoglossus major*, and from the *glossopharyngeus*, appear to be distributed only to the muscles and the glands, as we have shewn in pages 243 and 246: at least we are not certain that the filaments of the *glossopharyngeus*, which go to the incupped papillæ, are appropriated to the sense of taste, as we are still ignorant whether these papillæ enjoy that sensation; and the filaments of the same nerve, which some suppose they have traced to other papillæ, appear very inconsiderable.

The *tri-facial nerve*, or the fifth pair, which is distributed to all the organs of sense, appears alone to receive the impressions of taste, by the *lingual branch* of the *maxillaris inferior*, described in page 217; for this is the only nerve which is distributed to the teguments, in which it is evident the sensation resides; and it is also the only nerve, the ligature section or compression of which annihilates taste.

Such at least is the opinion now adopted by physiologists. It seems to us, however, that the anastomoses of the fifth and ninth pairs are so numerous throughout the whole extent of the tongue, that it is difficult to say which has the greater share in the filaments which go to the papillæ. The fungiform papillæ receive all of these

these filaments, which are sufficiently large to be traced by the naked eye; and this circumstance, joined to the hardness of the conical papillæ in certain animals, induces us to believe that the principal seat of taste is in the fungi-form papillæ.

The filaments which proceed to the papillæ below the point of the tongue, are more easily followed than those distributed to the superior surface, because the principal branches pass along the inferior part. The filaments which go to the upper surface soon disappear, by their tenuity in the substance of the flesh through which they are forced to pass. They ascend, in a parallel and perpendicular direction, to the surface, where they terminate.

The distribution of the nerves of the tongue present no essential difference in the three other classes of vertebral animals.

END OF THE SECOND VOLUME.

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